Energy and Geostrategy 2021

Spanish Institute for Strategic Studies

Spanish Committee of the World Energy Council
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SUMMARY

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Introduction

Claudio Aranzadi

This eighth issue of Energy and Geostrategy (E&G) follows the pattern established in the three preceding ones. It opens with the publication of an interview with a well-known public figure from the world of geopolitics or energy; in this particular publication, José Borrell, EU's High Representative for Foreign Affairs & Security Policy, explains his view on a wide range of current affairs in the energy geostrategy field. Five articles are then presented: by David Robinson, *The Impact of COVID-19 on the Energy Transition, a Global Approach*; Miguel Ángel Lasheras, *Geopolitics of the Green Deal: a Challenge for the European Union*; Thijs van de Graaf *Clean Hydrogen: the Cornerstone of a New Geopolitical Scenario*; Ricardo Prego, *Rare Earths, a Key Piece in the Energy Puzzle*, and Ignacio Fuente Cobo, *Energy Geopolitics in the Maghreb, the cases of Algeria and Libya*. Although the matters treated in each article are very different, the fact that energy transition is the central theme in each one, makes it possible to include common spaces for a reflection on the authors' work, as well as on the content of the interview with J. Borrell, thus providing a diversity of perspectives on the most recurrent topics in the analysis of energy geopolitics.

As is the case every year, when trying to pinpoint the changes that have affected the energy geopolitical scenario since the previous issue, there is no doubt that the COVID-19 pandemic and its impact on energy transition (a matter closely examined in the work by D. Robinson) plays a prominent role. The pandemic, just like the «Great Recession» brought about by the financial crisis that began in 2008, as mentioned with regard to the latter in E&G 2016, forms part of the statistically «rare» historical events (one would have to go back to 1918 to find a global precedent like the so-called «Spanish Flu», or back to 1929 to find another «Great Depression»). The main characteristic of statistically «rare» events (not frequent) is their relative unpredictability[1], and so, if they are particularly severe and catastrophic, Governments and International Institutions alike are poorly prepared to cope with them, which accounts for the mistakes that may have been made in responding to both the economic and the health crisis. However, in much the same way as the «Great Recession» brought about notable changes in the economic policy (for example, the widespread use of *quantitative easing* by the Central Banks as a monetary policy instrument), the recession, when faced with the supply shock caused by COVID-19, led to a radical redirecting of the taxation policy, a speeding up of innovations in healthcare technologies (rapid development of vaccines) and, at least in regional areas such as the European Union, a much closer cooperation between the Member Countries, leading to approval being given to a huge stimulation package amounting to €1.8 billion (adding up the EU's long term budget and the €750 thousand million for the Next Generation EU program, which aims to repair the immediate economic and social damage caused by the pandemic). Yet in his interview, J. Borrell considers that except for the European case, the health crisis has brought about a reduction in world cooperation (e.g. in supplying vaccines and masks).

It is clear that COVID-19 has had a disruptive effect on historic continuity and that it has caused major changes in the population's behaviour (modifying mobility patterns, increasing working from home, isolation, a trend towards staying away from urban centres, etc.), and that all of these have affected energy consump-

[1] C.A. Sims (2012), «Statistical Modeling of Monetary Policy and Its Effects», *American Economic Review*, indicates the limitations of the DSGE models when it comes to predicting events such as the Great Recession, not only for statistical reasons inherent to the models but also because of the insufficiencies in their specification. (See E&G. 2016).

tion. This begs the question of whether these modifications to the collective psychology will be structural, or if once the health crisis has been overcome, it will be back to «business as usual» i.e., just as it was before the pandemic. J. Borrell states that he does not believe there will be a return to the «old normal» and thinks that «we are at a global turning point, in the broadest sense of the term *global*». D. Robinson, in his article in this publication, points out that «COVID-19 has improved the prospects for energy transition and given greater insight into understanding how to bring it about». If we take into account only the energy sector, it seems logical to consider as reversible, the downward trend in energy consumption and CO2 emissions associated directly with the decline in economic activity. What are not so clear, are the effects on the energy consumption structure and on the display of energy technologies to attend the aforementioned population behavioural changes. Firstly, because in many cases, the modifications to the population's behaviour have had opposing effects. For example, the impact on oil consumption from the fall in the air transport demand has had the opposite effect to the impact from rejecting public transport. Secondly, because, although it would appear reasonable to expect some behavioural traits to remain where these affect mobility and the energy consumption structure, (for example, working from home), any future conduct changes affecting light transport for passengers will probably be determined more by the restrictions and taxation associated with energy policy, and by the effects of a trend towards greater rurality, and these changes are difficult to predict.

Whatever the case may be, accepting that a traumatic global event like COVID-19 will inevitably leave its mark, and this also applies to the energy sector, the global energy transition process, conditioned by such factors as the rivalry and cooperation network existing between States, the technological innovation, the national and international regulation of the energy markets, etc., will follow its own dynamics. The uncertainties surrounding the way the energy sector will evolve worldwide and the assessment of the «geopolitical risk» and of the growingly important «climate risk», are basically linked to the same set of variables to which attention was being paid before the pandemic. Nevertheless, this does not mean to say that the way these variables interrelate will not vary. Quite the opposite, the international energy environment is constantly changing, but it is subjected to forces that for the most part have nothing to do with the effects of the pandemic. That is why the orientation of any reflections about energy geostrategy in this publication could be deemed to keep continuity with what has been explained in the preceding issues.

If energy strategies are approached in the same way they have been in previous publications, i.e., as an optimisation programme (with a view to minimising the cost of supply, with restrictions owing to sustainability and security), it seems unnecessary to substantially alter this conceptual framework. In fact, the restriction associated with the imperative global decarbonisation from application of the climate policy (as it is defined in the 2015 Paris Agreement) will still be what basically determines the medium- and long-term energy policies and will still be an essential ingredient in the cooperation processes between States. However, the nature of these restrictions may be modified, not only by the changes in geopolitical balances, but also, and above all, by technological innovations. The rapid progress being made with the learning curve for wind and photovoltaic power generation technologies over the last decades is a clear example. Despite their incorporation into the power generation mix amounted to an extra cost, in a considerable number of countries and particularly in Europe (See the article by M.A. Lasheras), restrictions were imposed in the form of a minimum requirement for using renewable energies, justified on imperative sustainability and security requirements. These restrictions were «limitative» (the associated «shadow price», i.e., the marginal cost of tightening the restriction was positive). Once those technologies have become competitive in terms of cost, as is now the case, the restrictions no longer constitute a «limitation» to minimising the supply cost (the «shadow prices» would be zero) and, so, initially, government intervention would not be necessary for them to enter the mix (although, as we shall see below, the question is more complex).

Along the same lines, the energy geostrategy landscape could be significantly modified by changes in strategic direction, not only in the energy area but also in global foreign policy, made by political stakeholders who are essential to the international balance of power, such as the United States. Previous issues of this publication followed D. Trump's drift in foreign policy matters, from his penchant for protectionism and his mistrust of multilateralism to specific initiatives more directly associated with the energy sector, like his systematic break with B. Obama's initiatives in the international field (withdrawal from the Paris Agreement, withdrawal from the nuclear agreement with Iran) and on the domestic front (imposing a clearly lax attitude to environmental policies). As J. Borrell points out, not only the statements made by the new President J. Biden, but also his appointments (J. Kerry as special envoy for climate policy) and his first initiatives (cancelling the construction permit for the oil pipeline connecting the US to Canada, Keystone XL, etc.) all amount to a radical U-turn from D. Trump's political stand in the area of climate policy. The impacts of the Biden Administration's new direction in climate policy are twofold. Firstly, it enables the world's second biggest emitter (the first one is China) to return to a roadmap that is consistent with the Paris Agreement, thereby making a considerable contribution towards achieving the global emissions reduction target. Secondly, with proactive diplomacy where climate is concerned, it will strengthen what had been an isolated moral leadership of the European Union (with only 10% of the global emissions, the United Kingdom included) and will encourage co-responsibility from China (which has already committed itself to an emissions ceiling by 2030 and climate neutrality by 2060). In fact, as D. Robinson indicates in his article, with the USA re-joining the Paris Agreement and China's commitment, plus the declaration of more than one hundred countries that they are willing to take on the challenge of achieving climate neutrality by 2050, the process of decarbonisation by midway through the century seems to be on the right track, as this commitment has now been made by countries representing over 65% of the global emissions.

Even so, by clearly opting for a decarbonisation strategy for the US (i.e., progressively ceasing to use fossil fuels and replacing them with clean energies), Biden is facing a difficult dilemma, between climate policy and national security policy. «Energy dominance» as a major component of the US's national security strategy is largely based on the privileged position the country has attained in developing unconventional natural gas and oil, enabling the country to become the world leader in oil and gas production[2]. It could be argued that this definition of national security and «energy dominance» fits rather with President Trump's outlook, but it must be admitted that, in the uncertain but probably not in a too short period during which oil will continue to account for a significant proportion of the global energy mix, the US's energy independence and its strategic position on the energy markets are strengthened by the fact that it leads the supply of oil and natural gas. This will undoubtedly affect the rate at which

[2] «National Security Strategy of the United States of America». (December 2017).

domestic climate policy unfolds but, above all, it should lead to an energy policy and national security policy aimed at guaranteeing an «energy dominance» in decarbonised technologies (nuclear and renewables) where China, its main strategic rival, is progressing very fast. Furthermore, mention must be made of the strategic value of *tight oil* in the USA as a regulating mechanism for the global oil market that, unlike Saudi Arabia (with a centralised and politically dependent offer), can guarantee a response to the price fluctuations through a decentralised offer, without government impositions, and with such a rapid reaction to the market signals as is required by its shorter investment cycles and the decline rates, sharper than in the offer of conventional oil (E&G 2018, 2019, 2020).

The American diplomatic about-turn could also affect other world scenarios where geopolitical and energy factors are closely linked, such as Russia, Saudi Arabia, Syria, Turkey, Iran, Libya and Venezuela. Borrell mentions this in his interview. The potential resumption of the nuclear agreement with Iran, where Borrell himself also has a major role to play as a coordinator, is, undoubtedly the most ambitious challenge, given its repercussions not only on the oil market and nuclear proliferation, but also on the geopolitical balances in the Middle East. Borrell is aware of the difficulties involved in reconducting the agreement, but despite this he is moderately optimistic. As he states in the interview: «The Iranian Minister has assured me that they are prepared to comply with their obligations again on the nuclear question if the others comply with their part of the bargain regarding the economic questions. It should be possible for the USA to return to an agreement that has prevented Iran from becoming a nuclear power. But I foresee there may be difficulties in doing so». It is still too early to predict exactly what the about-turn in American diplomacy will be in the other scenarios mentioned, but it would appear to be clear that a new space is being created for developing the European «strategic autonomy» through more assertive geopolitical action from the EU (to which Borrell also makes reference in the interview); preserving, however, the spirit of cooperation within the transatlantic relationship. It is possible, for example, that new opportunities for collaboration between Europe and the US develop, conducive to a political transition in Venezuela that will make it possible to re-establish political and economic stability in the country, including a return to normal for its oil sector. Yet it will be more difficult for the EU to define an energy diplomacy with Russia that is perfectly in line with the US's (the case of the

North Stream 2 gas pipeline, mentioned by Borrell, is one example), although a greater diversification of the natural gas supply to Europe, in order to correct the excessive dependence on Russian gas, ought to be a strategic priority for the EU. This will mean increasing LNG imports and probably, as I. Fuente Cobo points out, attaching greater importance to the Southern Corridor of gas pipelines coming from Algeria; Spain could play a more prominent role in this strategy, not only because of the country's gas pipelines connecting it with North Africa, but also due to its gasification and storage infrastructure that, with a suitable interconnection network linking it to the rest of Europe, would help to enhance European supply diversification. Whatever the case may be, the biggest stumbling block to applying «strategic autonomy» in Europe, an aspect that is also dealt with by M.A. Lasheras in his article in this publication, will be the difficulties faced when it comes to getting all the EU Member States to adopt a unanimous position; a clear example of this, explained in detail by I. Fuente Cobo in his contribution to this publication, and which is also mentioned by Borrell, is the difference in criteria between European countries regarding the Libyan conflict.

As has already been pointed out, the United States' strategic shift on climate policy since Biden came into office will make it easier to forge a joint leadership policy between the US, China and Europe to establish a roadmap for the global decarbonisation policy that is consistent with the Paris Agreement goals and the conclusions of the IPCC (2018)[3]. The correction to the «national commitments» (which in their current form would lead to temperature rises close to 3ºC by the end of the century) which was left over for the COP 26, is going to require complicated geopolitical arbitration and, so, a coordinated diplomatic leadership despite the will expressed by a considerable number of countries to achieve climate neutrality by 2050; the question of Article 6 of the Rulebook will also have to tackled in COP 26, given that no agreement was reached on this point at the COP25 in Madrid and that it is of paramount importance to coordinating the mechanisms for mitigating climate change that have been put into practice by the different countries and regional areas (E&G 2020). Splitting the effort into different geographical areas is further complicated by the fact that the damage caused by climate change is not evenly distributed and it also depends on the efficiency of the mitigation

[3] Intergovernmental Panel on Climate Change (Special Report), «Global Warming of 1.5 ºC». (2018).

policies. Although given the global negative externality character of climate warming, a global «social cost» caused by that warming can be defined (the updated global damage of a marginal increase in emissions), it is clear that this «social cost» varies from one geographical area to another, and the same also applies to the «marginal cost» of the mitigation policies developed in each area.

But even though diplomatic deployment and the progressive development of liaising and global governance mechanisms are vital for the success of a global cooperation project like the Paris Agreement, there is a core axis that conditions the entire energy transition process, namely technology. Technological evolution not only determines the cost of each scenario proposed under the decarbonisation policy, but it also becomes its feasibility condition. As a result, any uncertainty regarding the way the learning curves develop for each technology, is thus a central factor in explaining the uncertainty surrounding the different roadmaps devised for the climate policy. Of course, the extent to which investment is made in science and technology, scale economies and *learning-by-doing* can all sharpen the learning curve gradient (that is what has happened, for example, with the sharp drop in the cost of generating electricity thanks to wind energy and, above all, photovoltaic energy in the past few decades). Even so, technological evolution also has its own internal dynamics, which is not always easy to predict: one only has to think, for example, of the constant postponing of the date for the successful outcome foreseen for nuclear fusion power, or what some have defined as a change of sign for the slope on the learning curve with the Third Generation nuclear fission reactors (although, as we shall see below, in this case the characterisation is more complex). With the global energy transition currently in progress, the rate at which new technologies are incorporated is so great that in the long term, it is going to turn an energy system where the core factor revolved around the availability of primary resources, into one where control over the technologies will be the main determinant where achievement in matters involving cost, supply security and sustainability is concerned. This logically means that, in the long term, in the energy area, the geopolitical relations of power between the main stakeholders in the sector, where control over primary resources will be the main asset, will move towards new interdependence relations associated with domination and transfers of technology.

The annual assessment carried out by the IEA (2020)[4] regarding the evolution of the technologies whose incorporation into the energy system is deemed necessary to achieve the transition to climate neutrality by about halfway through the century, considers that most of these technologies are not yet mature, whether this is in terms of cost or availability (IEA 2020)[5]. This creates a scenario of uncertainty that affects the cost of energy transition and even the feasibility of some of the roadmaps devised, what consequentially has a bearing on the «climate risk» associated with the energy activities. As is natural, technological uncertainty will be accentuated at the final phases of energy transition towards climate neutrality, since at the initial phases technologies that are mature or approaching maturity can be already counted on.

In this sense, the direction taken by the EU's energy policy (that M.A. Lasheras examines in detail in his article in this publication) is enlightening. In the framework established for the Union by 2030 – before the Green Deal – (which laid the foundations for preparing the comprehensive energy and climate plans, including the Spanish National Energy & Climate Plan (NECP)) and that considered the goal of reducing emissions by 40% (compared to the 1990 figure), there were no extraordinary technological requirements. The main courses of action for attaining that goal involve making progress with the decarbonisation of the power sector (boosted by a reduction in the cost of renewable electricity generation technologies), electrifying light passenger transportation (the prices of electric vehicles are expected to fall during this decade until they are on a par with the prices of internal combustion vehicles, while governments are expected to devise ways of encouraging the creation of a battery-recharging network of sufficient capacity), and in renovating buildings that at that phase did not require sophisticated technologies. Therefore, the goals for 2030 seemed to be attainable without too many difficulties. In fact, the European Commission[6], in 2018, forecast that with the policies approved, it would be possible to attain a greenhouse gas emissions reduction of 45% by 2030 (and 60% by 2050). However, at the same time, the Commission submitted a series of very demanding scenarios for achieving a 90% emis-

[4] International Energy Agency (2020 a). «Tracking Clean Energy Progress».

[5] International Energy Agency (2020 b). «Tracking Clean Energy Innovation».

[6] COM (2018). «A clean planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy».

sions reduction by 2050 plus the negative emissions needed to reach climate neutrality by that date, all of which would require the use of technologies which in most cases are not yet mature.

According to the European Commission[7], the addition of a new and more demanding goal for reducing emissions by 2030 (55%) under the Green Deal approved in 2020, and the application of supplementary measures during this decade, would make it possible to alleviate the transition in the period 2030 - 2050 to achieve climate neutrality. The investments required in the industry, services, transport and energy sectors would be considerable, but it would be possible to be able to count on at least 30% of the potential pluriannual budget together with Next Generation EU. In some aspects, such as in the power sector decarbonisation policy, the goals do not seem to be very demanding, because the prediction made by the Commission regarding the inroads made by renewable energies into power generation by 2030 is 65% (whereas the Spanish NECP predicted 74% in the framework previous to the Green Deal). Nevertheless, it is true to say that progress is expected to be made during this decade in the area of decarbonising heavy road transport, sea and air transport, and also in decarbonising industries. that had originally been left for the last two decades in the process of transition towards climate neutrality and that will require a large-scale incorporation of technologies that are not yet mature.

The weight of technological innovation on the global transition towards achieving climate neutrality by 2050, is clearly demonstrated in the analysis made in the IEA´s WEO for 2020[8], which for the very first time, examines systematically a scenario that is compatible with the target of net zero emissions by 2050. Until this latest issue of the WEO, the Agency had always included as its most stringent scenario from an environmental perspective, the so-called Sustainable Development scenario, which was in line with the Paris Agreement (limiting the growth of the world's temperature to well below 2ºC), not achieving though climate neutrality in 2050, but in 2070 instead, leading to a global temperature increase of 1.65ºC (with a 50% probability); according to the Agency, with a sufficiently intensive deployment of technologies that will facilitate negative emissions as from 2070, it

[7] COM (2020). 562 final. «Intensify European climate ambition for 2030. Invest in a neutral climate future for the benefit of our citizens».

[8] International Energy Agency (2020). «World Economic Outlook 2020».

would be possible by 2100, to reach the temperature increase limit of 1.5ºC (with a 50% probability).

Even in this scenario, less ambitious than the one that would achieve climate neutrality by 2050, the required energy transformation is considerable. In the WEO 2020 issued by the IEA, it is pointed out that in that scenario, by 2040 the demand for oil would fall to 66.2 M/bd (in 2019, before the pandemic was declared, the oil demand reached 97.9 M/bd) and all the coal plants would be either closed, reconverted or utilised as flexibility instruments for the electrical sector, operating for only a limited number of hours (WEO 2019). The required adjustment would logically be greater if the target were to have climate neutrality by 2050. Yet the WEO 2020 does not offer a quantified framework for the global energy variables in 2050, for the climate neutrality scenario on that date (it does so for their value in 2030 for this roadmap). The WEO 2020 however does provide insight into the technological challenges for that goal, and this view is very similar to what is shown in the European Commission's documents, or to what is shown in the documents prepared by the Member States that have drawn up long-term programmes (by 2050) as is the case with Spain in its «Long-Term Decarbonisation Strategy 2050» (which sets a 90% emissions reduction target, in line with the European target, a 97% share in the energy system for renewables, an electrification of the economy amounting to around 50% and 100% renewable energies used in power generation). In the first place, the technological challenges affect to the electrical sector, a key factor in the decarbonisation process, which still has to make progress in digitalisation and storage technologies if it is to be able to efficiently incorporate a massive variable renewable generation (with the uncertainty that affects the future of nuclear energy in the power generation mix), and to the electric vehicles with batteries that must complete the evolution of their learning curve. Secondly, and it is here where the biggest challenges have to be overcome, it is necessary to tackle the processes involved in decarbonising such activities as heavy road transport, sea and air transport and industrial sectors presenting considerable barriers to electrification. Two technologies will be playing a basic role in facing up to these challenges: the utilisation of hydrogen and the capture, use and storage of carbon. Green or low-carbon hydrogen will make a decisive contribution to the process of decarbonising, as a fuel, as component of other low-carbon fuels, as an industrial raw material, a storage vector and as alternative to electric vehicles with batteries (vehicles with «fuel cells»).

CO_2 capture, apart from being a necessary supplement for some technologies producing low-carbon hydrogen or hydrogen derivatives, also has great decarbonisation potential in power generation and in industrial processes, and, as can be seen in the IEA's climate neutrality scenario for 2070, it would be essential when applying technologies for extracting CO_2 from the atmosphere (negative emissions) necessary for reaching the limit of 1.5ºC by the end of the century.

Yet the evolution of the learning curve for these two key technologies at the most advanced phases of the decarbonisation policy is uncertain. Although there is tendency to extrapolate the success obtained with the learning curves for wind and photovoltaic generation technologies to these technologies, the technological risks are high, at least as regards the time schedule for incorporating them into the energy system as competitive alternatives. In fact, according to the data shown by Th. van de Graaf (who provides an extensive overview of hydrogen technology in his article in this publication), the estimates concerning the commercial potential for hydrogen by 2050 vary greatly from one institution to another (ranging from 1% to 18% of the final energy consumption). At present, hydrogen (or its derivatives, ammonia or methanol) are used in the oil sector, the fertiliser industry and other chemical industries, but generally in the form of «grey» hydrogen (obtained from reformed methane or, in the case of China, from gasified carbon and without CO_2 capture). «Blue» hydrogen (reformed methane with CO_2 capture) is logically more expensive to obtain than the variety where CO_2 is not captured, and this increase becomes considerably greater in the process for obtaining the «green» hydrogen variety (obtained by electrolysis of the water with decarbonised electrical generation): according to NEA/IEA (2020)[9], the «levelised cost»[10] of producing «blue» hydrogen ranges from \$1.2-2.0/kg.H2 compared to \$0.7-1.6/Kg.H2 for the variety without CO_2 capture; how expensive it is to produce «green» hydrogen obviously depends on the cost of the electricity used; NEA/IEA offers a wide range of costs for green hydrogen, ranging from approximately \$3 to 8 / Kg.H2, and it indicates that in locations

9 Nuclear Energy Agency/International Energy Agency 2020. «Projected costs of generating electricity» (2020 edition).

10 The «levelised cost» of production with a particular asset as defined by NEA/IEA is the constant average price in real terms of the goods produced that makes the total updated cost equal to the updated income throughout the useful life of the asset.

where renewable electrical generation could take place, this cost could be below $2 /KgH2.

In the future, hydrogen production will logically concentrate on the «blue» and «green» variety. Countries like Algeria or Saudi Arabia will tend to favour blue hydrogen; countries like Morocco or Chile, which are well-provided with renewable resources and do not have fossil fuels, will tend to produce green hydrogen; countries without any cost advantages in either area, such as German or Japan are already emerging as hydrogen importers. As Th. van de Graaf states in his article, the competitive edges in developing green hydrogen lie in the availability of renewable resources, fresh water and infrastructures, which under the hypothesis of hydrogen expansion would lead to a new global energy network of production, consumption and commercialisation. As Th. van de Graaf indicates, although some have described this scenario as a copy of the current oil scenario, it has more in common with the natural gas scenario (in fact, the hydrogen flows, when mixed with methane, could use the existing gas pipeline networks and, in the future, with reconversion investments, a purer hydrogen would be able to flow through them too).

Carbon capture, utilisation and storage is another of the key technologies in the decarbonisation process, but one where considerable progress in its learning curve still has to be made. The IEA[11] accepts this delay in its development (there were originally about thirty projects planned on a commercial scale in the world), it provides, however, an account of the future potential of this technology in a variety of fields: as has already been mentioned, CO2 capture is a prerequisite to obtaining «blue» hydrogen (from reformed methane), whose low-carbon content makes it a potential technological alternative to «green» hydrogen (obtained by electrolysis of the water with clean electricity); it could also be a technological option when it comes to reducing emissions in industrial sectors where decarbonisation is difficult to achieve, such as the steel industry or cement production; it is also a technological ingredient that is necessary in the production of carbon-neutral synthetic fuels from bioenergy or from the extraction of CO2 (thus opening its possible use to replace fuels in transport segments that are difficult to electrify, such as aviation); it would play a basic role, with the extraction of the CO2 emitted,

11 International Energy Agency 2020. «Energy Technology Perspectives 2020, Special Report on Carbon Capture Utilisation and Storage».

in enhancing a negative emissions programme, something that as we have seen, (for example in the Sustainable Development scenario of the IEA's WEO 2020) could be crucial in the second half of the century. This technology, applied to power generation, would make it possible to produce low-carbon content electricity from natural gas or coal. However, as indicated by NEA/IEA[9], the extra cost imposed upon power generation is considerable: it means that only the power generation with CO2 capture would be competitive, in relation to the technological variant without emissions correction with CO2 emission prices at $50/Tn of CO2 if electricity were to be generated with natural gas and $100/Tn if generating with coal. Yet as NEA/IEA indicates, if these CO2 prices were to be reached (through taxation or as a result of the «cap-and-trade» mechanism), this would only serve to make power generation with renewables and even nuclear generation more competitive.

As has already been pointed out, decarbonisation of the electricity sector will be until 2050 the main driving force behind the climate policy. In Europe, the target for this date is to obtain an almost totally decarbonised generation mix, with the presence of nuclear energy in some countries, but invariably with a predominance of renewable energies, (Spain's goal with its «Long-Term Decarbonisation Strategy 2050», is to reach 100% renewables in the power generation mix). Even though the sharp reduction in the cost of wind and photovoltaic electrical generation has greatly helped to achieve complete decarbonisation in the sector, there are still technological uncertainties and challenges, as well as regulatory uncertainties caused no doubt by the extreme technological changes that have already been and will continue to be recorded. The electricity supply is usually broken down into four types of service: energy, soundness (output availability), flexibility and grids; all of these will undergo major transformations throughout the energy transformation process.

Uncertainties even appear regarding the decarbonised power generation mix that will be imposed on the mid-century horizon. Power generation with natural gas or coal seems to have been ruled out in the long-term owing to the excessive cost involved in including CO2 capture, as has already been stated. Even so, thirty years from now it is difficult to imagine how the learning curve will evolve for this technology, given that it is at the early stages of commercial operation. Even greater uncertainty surrounds the weight that nuclear energy will have in the electricity generation, given the existence in this case of cost, safety/security, public opinion and geopolitical determinants. The potential future for nuclear energy in the decarbonised electricity generation mix is analysed both in IEA[12] and in MIT[13] publications.

NEA/IEA (2020)[9] considers that the option of extending the working life of Second Generation nuclear power plants so that they continue to operate 10 or 20 years beyond their design life is currently the option with the lowest cost for generating electricity. NEA/IEA's estimate for the levelised cost[10] of this option (which can be regarded as a metric of the total average cost), under the hypothesis of a 7% discount rate and a load factor of 85%, ranges from $31.2/Mwh to 41.1/ Mwh, which places it below the NEA/IEA's estimates for the levelised cost even of renewable wind or photovoltaic generation. Furthermore, the location of both wind and photovoltaic electricity generation facilities is a crucial factor when it comes to cost, so the latter tends to vary a great deal. For example, in Spain, the average costs judging by the bids made in the most recent renewable generation auction, were clearly lower than the levelised cost figures for electricity generated at the nuclear power plants with an increased working life offered by NEA/IEA.

The situation is completely different for the new Third Generation plants. The first plants were affected by considerable delays in their construction periods, as well as major deviations from the original budgets, all of which have a negative effect on the cost of generation; for example, the generation cost accepted (i.e. the «strike price» in its Contract by Differentials) for Hinkley Point C, in the United Kingdom is 92.5 £/MWh for 35 years (which could be reduced to 89.5 £/MWh if certain conditions are fulfilled). As the NEA/IEA indicates, it is true to say that these «first-of-a-kind» reactors featuring a new technology always have extra costs and that the experience gained from learning during their construction projects leads to a significant reduction in the cost of the subsequent reactors. The «levelised cost» figures for generation, once this first phase has been overcome, which is quoted by NEA/IEA (under the hypothesis of a 7% discount and a load factor of 85%) would be considerably lower (around $71/MWh in France and the USA, $66/MWh in China and India,

[12] IEA (2019). «Nuclear power in a clean energy system».

[13] MIT Energy Initiative (2018). «The future of nuclear energy in a carbon-constrained world» (An interdisciplinary MIT study).

and $52/MWh in Korea). Notwithstanding, NEA/IEA[9] has a more optimistic vision of the potential of «small modular reactors» of the light-water type, because of the radical changes made to the way the construction is arranged (a greater emphasis on manufacturing the components at the factories and their subsequent assembly *in situ*), the possibility of modulating the investment, the access to locations where high-powered reactors cannot be accommodated, and the technological optimism, also applied to other Fourth Generation reactors.

With the costs shown in the latest report issued by the NEA/IEA and, given its potential for providing the electrical system with soundness and flexibility, nuclear electrical generation could have a certain share in the decarbonised generation mix. However, the main drawback is that it is rejected by a significant proportion of the general public (a percentage that varies from one country to another) that does not trust the safety of the nuclear facilities, especially after the Fukushima accident in Japan. Although the risk of a nuclear accident (quantified as the product of the damage expected in terms of its likelihood, plus a risk premium) constitutes only a small part of the total cost of nuclear generation[14], a certain proportion of public opinion considers this risk to be much greater than is generally estimated and thinks that the continued use of this technology is unacceptable (in fact, this percentage of opinion implicitly expects any potential damage to be almost infinite to the extent that even the fact that the likelihood of accidents with the new nuclear technologies is very low, this does not reduce their perception of the risk). This state of affairs has affected the political positioning of European governments in different ways. Some countries, such as Germany and Spain have chosen to abandon nuclear technology, whereas others like France and the United Kingdom are expected to carry on relying on nuclear power generation in the long term. Certain geopolitical factors condition this choice. It seems unlikely that countries which still consider nuclear arms to be a central element in their defence strategies will opt for abandoning the civil uses to which this energy can be put. This would partly account for the French and British stances on nuclear power. Where France is concerned, industrial policy also plays a role: nuclear technology is an industrial niche where France is in an outstanding position. Be that as it may, arguments of a geopolitical nature may be utilised to

[14] F. Lévêque (2015), «The economics and uncertainties of nuclear power». (Cambridge University Press).

justify the continuity of nuclear technology both in the US and in Europe. M. Bowen[15] describes the risk of US disinvolvement in exporting nuclear technology, which would mean a reduced ability to exert influence on international agreements dealing with technical and security regulations and this could also even have a bearing on nuclear non-proliferation policy. According to Bowen, the data concerning the number of nuclear plants constructed or in the process of being constructed since 1997 in China, indicate that they are more than four times those in the US, while the number of plants in Russia nearly triple the US's (besides, most of the ones in Russia being exported). Moreover, apart from the advantage that this gives China or Russia in the evolution of the learning curve, it also enables those two countries to obtain considerable strategic advantages through exporting nuclear technology to sensitive areas such as the Middle East.

The variable nature of renewable power generation also imposes technological requirements if it is to be able to efficiently integrate these technologies on a large scale (in countries like Spain, renewable energy is expected to account for 100% power generation by 2050). This situation will require the development of a major offer of sound and flexible services, charged to the available generation capacity, the smart management of demand, interconnections and storage (above all, pumping and batteries), which means enhancing the digitalisation of the electricity system and a breakthrough in storage technologies not yet fully mature. Developing distributed resources (generation and storage, plus the sharp growth in domestic consumption) also poses considerable technological challenges with respect to efficient integration with the most centralised resources; the grids, above all, that are going to find themselves faced with the generalisation of two-directional flows coming from multiple network nodes, are going to require the large-scale incorporation of information & communication technologies (smarter networks)[16].

In the next few years, these major changes affecting the technological structure of the electricity sector will take place at the same time as its institutional and corporate architecture undergoes a far-reaching transformation that will also greatly affect

[15] M. Bowen (2020), «Why the United States should remain engaged on nuclear power. Geopolitical and National Security Considerations». (Columbia/SIPA. Center on global Energy policy).

[16] C. Aranzadi (2019), «Distributed electricity storage workshop. Introduction». (Think Hub. Fundación Caminos).

the composition of the agents that operate in that sector, the business models, the contracting mechanisms and, ultimately, its regulatory framework. The paradigm for the liberalised electricity models that first became widespread in the 1980s had a wholesale energy market whose prices were the important signs not only for an operation but also for an investment efficient in generating electricity. Although the «energy only market» model did not function in its purest form hardly anywhere (the added factor of the «capacity markets» or other mechanisms aimed at making up for the «missing money» on the energy markets became quickly widespread), the basic logic of the new liberalised models was able to remain in the system where conventional generation (nuclear, coal, natural gas) was predominant. The predominance of generation technologies whose variable costs are close to zero and variable in operation (as is the case with wind and photovoltaic energy generation) disrupts the essential nature of the current model. The average prices on the wholesale market will continue their downward trend in the medium and long term (as a result of the growing share in electrical generation of near-zero marginal cost generation technologies in the short term), which means that in the payment of the electricity supply, the weight of the revenues on the wholesale energy market will tend to decrease and, therefore, the dependence of the electricity business on payment for the soundness services (capacity markets), flexibility services (supplementary service markets managed by the system operator) and grid services (whose payment as natural monopolies is fixed by the regulator), will increase accordingly[16].

D. Robinson (in his article in this publication) argues in favour of a «double-market» model[17] to cope with the prices trendy evolution on the wholesale energy market, with the need to considerably increase the flexibility offer and to accommodate the complexity of the expected increase in the resources distributed, so that the progress made in the digitalisation of the electricity sector can guarantee their implementation. Whatever the case may be, the regulatory evolution would appear to lean towards a model with strong «single purchaser» characteristics, as is the case with Spain. Even if the «capacity markets» (where the volume of available capacity required or the demand curve con-

17 D. Robinson and M. Keay (2020), «Glimpses of the future electricity system? Demand flexibility and a proposal for a special auction».(The Oxford Institute for Energy Studies).

structed were already established by a centralised administrative body) or the flexibility markets (where the system operator obtains the reserves and other adjustment services in a centralised way) were to use competitive mechanisms to allocate the offer among the end suppliers in their respective markets, the definition of and guarantee for a certain soundness and flexibility standard has been corresponding to a central body (i.e., they were «one-sided» markets). These services were implicitly considered to be a public asset. Most probably, soundness and flexibility will continue to be managed in centralised form in the future, although it could be suggested that the development of digitalisation will enable the end suppliers and the end demanders of those services to cross over in those markets (making it possible to distinguish between the demanders on the basis of their preferences for both services, and supressing their characterisation as a public asset). However, it is perhaps the wholesale energy market that is drifting further towards a direction that is consistent with the single purchaser logic. As the renewable electricity generation offer allocation increases (or in the case of the United Kingdom, nuclear electricity generation) through the auction procedure where the «strike price» is established in contracts by differentials that may differ from both the «spot» wholesale market price profiles and the fix-term prices in bilateral contracting (for example in the form of Power Purchase Agreements), it is established that a growing proportion of the energy offer is allocated in a «one-sided» market (the auctioned volumes are fixed by an administrative body) and where the «strike prices» yielded from the auction mechanism actually represent «standard costs» albeit determined by a competitive mechanism. The model's logic has a lot in common with the logic that characterised the Spanish wholesale market under the LOSEN Act (1994).

This technological centrality affecting the energy transition process manifests itself in many ways. Firstly, the uncertainty surrounding the availability and evolution of the learning curves for the different technologies involved in the process (most of which, as the IEA points out, are not yet fully mature) means that the technological risk becomes a significant contingent cost. This uncertainty is accentuated still further by the competition between some new technologies whose deployment is announced for the next thirty years. A clear case is the one described by Th. van de Graaf, in his article in this publication, in which the competition is illustrated between the use of hydrogen and a more direct energy cycle (with different efficiencies in the set of energy conversion processes required) for electricity end uses not only for mobility but also for the refurbishment of residential buildings. Furthermore, most of the new technologies that will be involved in the energy transition are capital intensive, which will mean, in addition to a considerable investment outlay (with high discount rates applied owing to the high technological risk), a greater proportion of «sunk costs». In this context, it is highly likely that there will be «stranded investments». Some examples have already arisen in conventional power generation: a significant reduction in the number of hours that combined cycle natural gas plants are used as renewable generation sources increase their share of the market, decommissioning or reconversion of the coal plants (a process that, as is indicated in WEO 2019 issued by the IEA, is going to have a major impact on Asian countries investing heavily in these plants that have only been operating for short periods of time). In the oil sector, the risk of «stranded investments» will depend on the extent to which the planning for the new investments is adjusted to the overall impact of the evolution in oil demand and the depletion of wells, although it seems inevitable that in the long term, a considerable proportion of the underground resources in countries with huge reserves will become «stranded assets» if the climate neutrality targets are to be achieved by 2050.

Secondly, the future technological scenario associated with energy transition will also have major geopolitical effects. The advantageous geostrategic positioning that some countries enjoy because their abundant fossil fuels (especially if, as is the case with oil, these resources are concentrated in certain geographical zones) will gradually decline as the overabundance of resources in the long term becomes evident; the contribution of certain geographical areas, such as the Middle East or some «choke points» on the oil traffic routes, to determining the geopolitical risk on the energy markets will also become less important. The control over decarbonised technologies and the availability of mineral resources containing elements associated with these technologies, such as «rare earths», (to which Ricardo Prego devotes his article in this publication), and other critical materials, will progressively displace fossil fuels as an «energy dominance» factor in the international relations. It is true that technologies spread, but the «first moving» normally has a significant strategic advantage. That is why the geostrategic importance of China's growing advantage in decarbonised technologies must be stressed (not only regarding nuclear energy but also regarding renewable energies), a question addressed by I. Tapia in the preceding issue of E&G. Moreover, China has achieved a predominant position by having the mineral resources needed to develop decarbonised technologies, namely «rare earths», whereas the US and Europe have been late in reacting (See the article by R. Prego). China will obviously continue to benefit from this scale effect by using such resources for its technological development in all energy areas as its learning curves evolve. Although technological distances can be shortened with a suitable policy for investing in research and infrastructures, correct planning and allocation of resources in the medium and long term are necessary to minimise the cost, in an environment of great technological uncertainty like the one created by energy transition. Furthermore, although it is true to say that the predominant primary energy resources of the future in the long term (sun and wind) exist in all geographical areas (albeit with different intensities), location is a crucial factor when it comes to the cost of production using these renewable energies, which will lead (in view of the major differences in cost) to a new international specialisation and a new network of global energy flows (Th. van de Graaf examines this question where hydrogen is concerned), which will affect the global network of energy infrastructures.

Questionnaire

Josep Borrell Fontelles

The COVID-19 pandemic has caused a major breach in historical continuity. Firstly, owing to its impact on economic activity and energy consumption (and its effect on CO2 emissions). Secondly, due to the way it has modified the population's behaviour and their collective psychology (changes in movement patterns, working from home becoming widespread, isolation, etc.). And thirdly, because of the way it has spurred on the development of innovations in the area of health care technologies and has helped to achieve a more cooperative political conduct between nations (for example, the EU Next Generation Programme). Do you think the changes brought about by the pandemic will be transitory and that once we get back to normal health-wise, it will be «business as usual» again, shall we witness a structural transformation?

No, I don't think we'll be back to the old normal. Pandemics have been major vectors for change throughout human history. My experience of the crisis from the post of HR/VP has made me understand that we're at a global turning point, and I mean global in the broadest sense of the term. Not even the World Wars were really «world» wars, and previous pandemics did not affect as many countries at the same time.

I think the consequences will be somewhat more than steepening the gradient of a linear evolution. They'll affect globalisation, the role of the State, world governance and multilateralism, which was already in crisis. They'll also affect competition between the political systems in a liberal democracy and the systems with different degrees of authoritarianism.

In everyday life, the pandemic has speeded up the use of online commerce or videoconferences and has generated new dynamics, such as a move from cities to rural zones. How each one of these changes takes root and what their net effect will be on the global energy demand remain to be seen.

Do you think the aftermath of the pandemic could have any effects on the way the long-term geopolitical scenario evolves?

Many! The world will be more digital, more unequal and also more Asian, given that Asia, and especially China, is emerging stronger from the pandemic. COVID has accentuated the rivalry between China and the US. What you're saying about more cooperative behaviour between countries is true among the Europeans with Next Generation EU, but I can't see that this crisis has increased world cooperation in general. I'd say the opposite has happened. There hasn't been enough cooperation, but there has been confrontation between powers to show which one has been the most efficient and which one has done most to help the others, first with masks and now with vaccines.

The European Union and the Western Countries have been having difficulties when it comes to providing developing countries with vaccines in the way that we are expected to and we should have done. It is undeniable that China and Russia have managed to act more quickly and that'll have geopolitical consequences.

In the US, President Biden's Presidency has announced that the country will be re-joining the Paris Agreement and will possibly re-join the Nuclear Agreement with Iran, and that generally, the US will be returning to multilateralism. From a European viewpoint... How do you think this will affect the energy and climate geostrategy?

It will clearly have an enormous effect! Just for the two reasons that you've mentioned, climate and Iran, the world will be much better and a safer place. President Biden has already kept his promise and signed the Decree that paves the way for the US's return to the Paris Agreement that it left on 4 November last year. We have already had the first videoconference with his Special Envoy for Climate, John Kerry, who shared with is a «much more humble yet ambitious» plan. But they'll have to work hard to make up for the years of damage caused by Trump. The United States has promoted climate change negation and encouraged this attitude in major countries like Brazil and Saudi Arabia. The United States is the second biggest emitter on the planet, but it has only paid one out of the three thousand million dollars it promised to the Green Fund for Climate. However, the rectification is now crystal clear: Biden has revoked the construction licence for the Keystone XL Oil Pipeline and has ordered a moratorium on the use of oil concessions in the Arctic, etc.

But the world has changed and is no longer the world of Paris 2015. Other stakeholders such as the EU and China are executing outstanding activities. The United States will have to set more demanding climate targets for 2030 before the COP26 Conference. Biden will have to put climate neutrality by 2050 to the vote in order to equal the commitment made by China, and there is no doubt that he will have to face a powerful lobby in opposition when he tries to apply his green relaunching plan.

We are waiting for the United States at the G20 and at the world climate summit that Biden has undertaken to call in the first 100 days. And of course at the COP26, too. There are great expectations and what will be important are the specific commitments.

And regarding the nuclear agreement with Iran, the Joint Comprehensive Plan of Action (JCPOA)? Are you optimistic about the possibilities of revitalising the nuclear agreement with Iran or replacing it with an agreement with broader scope?

In my capacity as coordinator of the JCPOA, I've tried to keep the agreement alive after the US withdrawal. We are now waiting to see what the new Biden Administration decides to do.

Until Trump withdrew from the agreement, Iran had fulfilled its part. Now, both the US and Iran have expressed their willingness to take up the agreement if there is reciprocity on both sides regarding compliance.

The Iranian Minister has assured me that they are prepared to comply with their obligations again on the nuclear question if the others comply with their part of the bargain regarding the economic questions. It should be possible for the US to return to an agreement that has prevented Iran from becoming a nuclear power. Though I foresee difficulties in doing so.

To what extent might the US's return to a more conventional diplomacy affect the inflection in the EU's foreign action towards being more geopolitically assertive and having greater strategic autonomy, something that the experts attribute to your mandate as High Representative?

With Biden as President, there is a significant increase in opportunities for collaboration with the EU. Europe's strategic autonomy, which is a position that I definitely defend and that has nothing to do with protectionism or isolationism, is not directed against the United States. It is simply that Europe is to be capable of acting on its own account whenever necessary. A stronger and more united Europe would be a better ally. And this should also be of interest to the United States.

Although the expected return of the US to the Paris Agreement increases the possibilities of success at the Glasgow´s COP26, the difficulties in achieving an agreement regarding the questions that are still pending approval from the COP held in Madrid (mainly concerning the devising of a mechanism for coordinating the instruments for the state or regional mitigation policies and the urgent correction of the national commitments to reduce emissions) are still considerable. Do you think that Europe can play an active role in the effort to achieve a convergence of positions from those who are party to the Agreement?

As is said before, the United States has returned to Paris Agreement, but it has to meet its duties. And so do us. We have set the standards very high, and it is not going to be easy to achieve them. However, as Europe (excluding the UK) only generates 7% of the world's emissions, even if we were to miraculously stop emitting even one sole gram of CO_2 tomorrow, the problem would still be the same, because there would still be the other 93% to consider. So, what we have to do is to get the biggest emitters, including the US and China, to move in the same direction and, above all, we have to ensure that the increase in energy consumption that must take place to meet the developing countries' needs is produced in a sustainable way. Our climate ambition is one of the signs of identity of this Commission, but we have to understand the problem globally and work hard and actively on the diplomatic front to ensure we don't stand alone in the attempt. At the COP26, the United States, China and the EU all have to pull together, and row in the same direction.

And how can this great increase in energy consumption be combined with a reduction in emissions?

The world has two energy problems. The first problem is that those who have access to energy produce greenhouse gas emissions that are too high. That is what receives most attention in our developed world. But there is another global energy problem that is just as big: energy poverty. That makes hundreds of millions of people to lack access to sufficient energy, with terrible consequences for them and for the environment. When you travel through Africa you realise this. The green and digital future cannot be constructed on such uneven energy consumptions per capita. The richest 1% in the EU emits an average of 43 tonnes of CO2 per year, nine times as much as the world average of 4.8 tonnes. The average US citizen emits more CO2 in four days than the inhabitants of Ethiopia, Uganda or Malawi in a whole year. What is more, the inhabitants of the latter countries use very primitive fuels and technologies. Firewood provides more than half the total energy consumed in East, Central and West Africa.

That is a description of the problem, or of the problems, if you like, but you haven't said anything about the solutions.

True, and I haven´t finished describing the problems either. Energy poverty has an enormous cost in terms of human health. Now that we are suffering a major pandemic that affects the respiratory tract, it is good to know that the WHO considers that air pollution indoors is, or was before COVID arrived, the biggest environmental health risk in the world for the poorest people and causes 1.6 million deaths every year. Furthermore, it contributes to the deforestation of the planet.

The solution can only come from cheap, safe and low-carbon technological alternatives to fossil fuels, at large-scale. Without them, we will not enable poor countries to meet their needs or rich countries to change their current unsustainable model.

I know I am stating the obvious, but that is what must be done, and we still haven't done it. The energy transition requires large-scale technological innovation.

We are doing it, developing renewables is a good example. What more must be done and what geopolitical consequences will this technological transformation have?

Well, we're doing it more quickly now, but not in all sectors. In electricity production we have developed alternatives to fossil fuels. But if my information is correct, the proportion of renewable energies plus nuclear energy still stands at about 35%, and in percentage terms it has not improved for thirty years. In other sectors we are not yet finding a solution.

But, when we do find a solution, the requirements of the climate policy brought together in the Paris Agreement will, in the long term, lead to a global fossil fuel demand profile that could make a large proportion of the resources currently existing to become «stranded assets», reducing the strategic importance of pivotal countries in the oil market, such as Saudi Arabia or Russia. Once again … What are the geopolitical implications of that transition in a world with an overabundance of fossil fuel resources?

Much greater than what we think. In my postgraduate days at the French Oil Institute in Paris in 1982, I was told there was oil for 50 years. Now, we are talking about an overabundance of assets that will lose their value owing to climate restrictions. A reduction in fossil fuel demand will certainly lead to changes in the degree of geopolitical influence exerted by countries that currently use those fuels to finance their own welfare. That is why some of them frown upon our climate ambitions, and that includes countries in our immediate vicinity. Without suitable planning, there could be new areas of instability instigated by the regional stakeholders affected. The climate factor is going to change the distribution of wealth in the world. Very rich countries will be less wealthy and others that are currently poor will find that the value of their natural resources increases. Think of all the lithium there is in the Andes, and it is needed for batteries. It is not a neutral matter from a geopolitical perspective, and it won´t happen without resistance.

Electricity and hydrogen are going to be two essential energy vectors in the decarbonisation policy. Renewable electrical generation (photovoltaic and wind) is now fully competitive in relation to alternative technologies. However, the cost of producing hydrogen is not yet competitive with the technologies available. Are the measures taken in Europe sufficient to help progress to be made in the learning curve for hydrogen production technologies?

I'm convinced that hydrogen has a role to play in the future of the energy/climate binomial. Especially the so-called green hydrogen, which is produced from photovoltaic electricity. Last July, the EU announced its European Hydrogen Strategy with the ambitious target of generating 40 GW using this source by 2030. In countries like Spain, generation companies are showing great interest in hydrogen. Portugal and the Netherlands are already working together on production and transport projects and Germany and France are also collaborating on large-scale projects. The experience obtained while developing photovoltaic and wind energies must serve to devise an incentives structure that facilitates the development of this technology. North Africa could be a very suitable place for production, given that we already have a gas pipeline network linking it with Europe.

With respect to alternative supplies by gas pipeline or in the form of LNG, Russia could be considered a potentially competitive supplier (in production and transport cost) of natural gas to Europe, in the long term. Yet the proportion of Russian gas imports in the European demand seems excessive. Shouldn't Europe seek greater natural gas supply diversification, for energy security reasons, as regards geographical origins, modes of transportation and contractual characteristics?

For a long time, European countries have lacked alternatives to Russian gas supplies. At present, Russia accounts for 40% of the gas imports to the entire EU, and between 80% and 100% of the supply to such Member States as Slovakia and the Baltic countries. Yet it isn't the supply percentage but the availability of alternatives that gives a realistic image of the EU's energy security situation. And from that perspective the EU's situation has improved in the last 15 years, thanks to internal legislation and infrastructure, including the diversification of its import sources via the South Corridor and new LNG terminals that have connected us to the global market.

Furthermore, as the Green Deal develops, purchases from Russia will progressively decrease. Therefore, although Russian gas purchases are still considerable, the EU Member States that are purchasers now have a bargaining power they lacked before.

To what extent is energy diplomacy with Russia being considered in the EU's Energy Diplomacy Action Plan?

To tell you the truth, I must admit that there is no reference to any particular country in the recent Conclusions issued on 25 January by the EU Foreign Affairs Council on climate & energy diplomacy. The aim is to promote an ambitious green energy transition on a world scale, including the gradual removal of investments in fossil fuels; it also stipulates that «the EU's energy diplomacy will discourage any further investments in fossil fuel-based energy infrastructure projects» and it will guarantee energy security.

And what can you tell me about the controversial Nord Stream 2 in these moments of tension with Russia? To confront Russia, must it be halted?

You're certainly putting me on the spot… This matter was not considered in the recent EU Foreign Affairs Council of EU Ministers, but there are countries that would like to use this lever in their relations with Russia although, as the French Minister Jean-Yves Le Drian stressed publically, it is Berlin's responsibility to do this. An overwhelming majority at the European Parliament has asked for the gas pipeline to be closed immediately, and it is also a bone of contention between Berlin and Washington, which is imposing extraterritorial sanctions on the European companies involved. But let's be realistic. The Nord Stream 2 gas pipeline is a €10,000 million project that is 90% complete and it'll double the capacity for sending Russian gas to Germany. It certainly does not help to diversify energy supplies to the EU and the Commission has stated that it does not consider it a priority, it is understandable however that Chancellor Merkel is not prepared to throw the investment down the drain.

The discovery of natural gas deposits in the Eastern Mediterranean and the Black Sea has added a new source

of tension to a region of considerable strategic importance to Europe, as it affects the European south-east energy supply route. What position will the EU adopt in this regional area and, more specifically, with respect to an essential stakeholder like Turkey?

Exploiting these deposits ought to provide a source of revenue with which to give a boost to prosperity in the region. The European Union is working on a solution that stands up for the Member States' interests and that is accepted by Turkey. The Turkish Minister of Foreign Affairs told me recently that a solution to the sharing out of revenue from these gas deposits would help to solve 50% of the relation problems between the EU and Turkey, especially regarding the situation in Cyprus.

I think the solution must be found within the framework of the negotiations that the United Nations has undertaken to begin soon pursuant to the partition of Cyprus. However, it'd be a good idea to consider that at a time when attempts are being made to boost ecological transition, launching operations of doubtful future profitability in a zone that is ideal for developing renewable energies doesn't make much sense.

Talking of China, the election of Biden would at least amount to a new diplomatic style when tackling relations with China, even while keeping up the strategic rivalry between the two countries. What space is left for Europe in the balance of geopolitical power between the two powers?

Whatever space we want, depending on our political will to use our economic and commercial dimension and our investment and technological capacity to defend our interests.

The United States and Europe enjoy a political system based on alternating power through elections, share a market economy system, and we have a long-standing alliance, we are not equidistant therefore in the conflict between the United States and China, that is going to shape this century. For both, China is at the same time an adversary, a competitor and a partner, depending on the subject concerned.

Nevertheless, Europe has its own interests. Developing and defending those interests is in no way detrimental to the United States. One such example is the recently signed Investment Agreement with China. But we must do things our way by pursuing what some have referred to as the Sinatra Doctrine. Europe cannot be fenced in by this conflict and must be able to defend its own interests, which don't always coincide with those of the United States, even if we do basically see eye to eye.

While we're on the subject of China, in a process of global decarbonisation of the energy sector, as required by the climate policy, the competitive and strategic advantages in the sector no longer lie in the reserves of primary fossil fuel resources, they now revolve around leadership in the development of decarbonising technologies and around controlling the rare earth materials needed to operate those technologies. In both areas, China is making major breakthroughs. Is Europe preparing to play a major role in this area?

In September 2020, the EU drew up a plan of action entitled «Critical Raw Materials» in response to this challenge. The EU is working with partners such as the USA, Canada and Australia and in regions of Latin America to develop a strategy for guaranteeing the sources of the raw materials needed for the European demand.

You have referred to the importance of Europe's transatlantic relationship with Latin America. In the energy field, the future of a country with oil reserves like Venezuela is of great importance. What contribution can the EU make to breaking the deadlock affecting the Venezuelan situation, at a time when Biden's access to the Presidency would appear to give greater room for geopolitical manoeuvre?

Our contribution would be to carry on doing the same as we've been doing so far: support the Opposition while at the same time call them for unity and pressing Maduro's Government so that a solution involving presidential and legislative elections that can be recognised by the international community may be negotiated. A new US Administration can contribute to creating the incentives for ensuring that these negotiations, which so far have failed, can prosper.

Libya, a major actor in the oil sector, has initiated a process of dialogue to guarantee peace in the country, under the auspices of the UN and the EU. How do you expect this process to evolve?

The Libyan conflict is still one of the most complex ones in the vicinity of the European Union. In Libya we are paying the price of our division. Some Member States have favoured one of the contenders, while others have supported the other. Meanwhile, Turkey and Russia have played major roles as they've done in Syria. Now, Turkey can bring influence to bear on the Central Mediterranean route for immigrants heading for Europe. The EU has deployed Operation Irini to enforce the arms embargo and the situation is relatively stable. The EU is about to create the figure of Special Envoy to establish the necessary dialogue with the important stakeholders and to make progress in finding a solution that'll have to come from the agreement by the Libyans themselves.

Chapter one

The impact of COVID-19 on the energy transition: a global perspective[1]

David Robinson[2]

Abstract

There is no compelling reason to be optimistic about meeting the goals of the Paris Climate Agreement. However, despite its devastating effects on world health and prosperity, COVID-19 has perhaps created the opportunity for governments and companies to accelerate an energy transition that was already underway and gathering steam. The consequences of the pandemic and the responses to it may provide some glimpses of the future decarbonised energy system and guidance on how companies and policy makers should prepare for it. COVID-19 has certainly provided the justification and the opportunity for governments to loosen their purse strings to support a green economic recovery in a number of major countries – a recovery that not only helps to provide short-term relief, but also to build for a more sustaina-

[1] This chapter draws on some of the ideas and articles from «COVID 19 and the Energy Transition», Oxford Energy Forum 123, July 2020. The views are however the author's.

[2] The author would like to thank Rocío Rodríguez-Villanueva for her comments, as well as research and editorial assistance. He would also like to thank Michael Tennican for his advice and comments. Any remaining errors are the author's responsibility.

ble future. Finally, the pandemic has laid bare other global problems – notably limited governmental resources, lack of resiliency, income inequality, trade tensions, debt and poverty – that will inhibit the energy transition. It has also demonstrated the importance of the international cooperation that will be required for a successful global transition, which in turn will help address the other problems. In short, COVID-19 has improved the prospects for the energy transition and provided a better understanding of how to realise it. It remains to be seen, however, whether we will take advantage of this unique opportunity.

Keywords

Energy transition, COVID-19, glimpses, decarbonisation, geopolitics.

THE IMPACT OF COVID-19 ON THE ENERGY TRANSITION: A GLOBAL PERSPECTIVE

COVID-19 IS CREATING SUITABLE CONDITIONS FOR ACCELERATING THE ENERGY TRANSITION.

PRESSURE TO ACCELERATE THE TRANSITION

THERE WAS STRONG PRESSURE BEFORE COVID-19 AND IT HAS INTENSIFIED DURING THE PANDEMIC, ESPECIALLY FROM THE FINANCIAL SECTOR.

LESSONS FROM COVID-19 THAT SUPPORT THE TRANSITION

WITH RESPECT FOR NATURE, LONG-TERM VIEW, EARLY ACTION, GLOBAL COOPERATION, SUPPORT FOR SCIENCE & INNOVATION, COMPETENT GOVERNMENT THAT TACKLES SOCIAL CONCERNS.

GLIMPSES OF A FUTURE DECARBONIZED ENERGY SYSTEM

COVID-19 HAS PROVIDED EARLY SIGNALS THAT HELP POLICY MAKERS AND ENERGY COMPANIES TO PREPARE FOR THE FUTURE.

GREEN RECOVERY

THE RECOVERY ENABLES GOVERNMENTS TO MEET SHORT-TERM ECONOMIC NEEDS AND ENCOURAGE INNOVATION AND PRIVATE INVESTMENT FOR A MORE SUSTAINABLE FUTURE.

WORLD TRENDS AND PROBLEMS

COVID-19 HAS INCREASED TRADE BARRIERS, POVERTY AND DEBT IN DEVELOPING COUNTRIES. CONDITIONS ARE NOW SUITABLE FOR IMPROVING INTERNATIONAL COOPERATION THAT WILL HELP TO DEAL WITH THESE PROBLEMS AND ACCELERATE THE GLOBAL ENERGY TRANSITION.

SIGNS OF A FUTURE DECARBONISED ENERGY SYSTEM

1 THE ENERGY TRANSITION MEANS CHANGES THAT AFFECT THE ENTIRE ENERGY SYSTEM AND IMPROVE SUSTAINABILITY

2 EARLY NOTIFICATION ABOUT POSSIBLE CHANGES SERVES AS A WARNING TO GOVERNMENTS

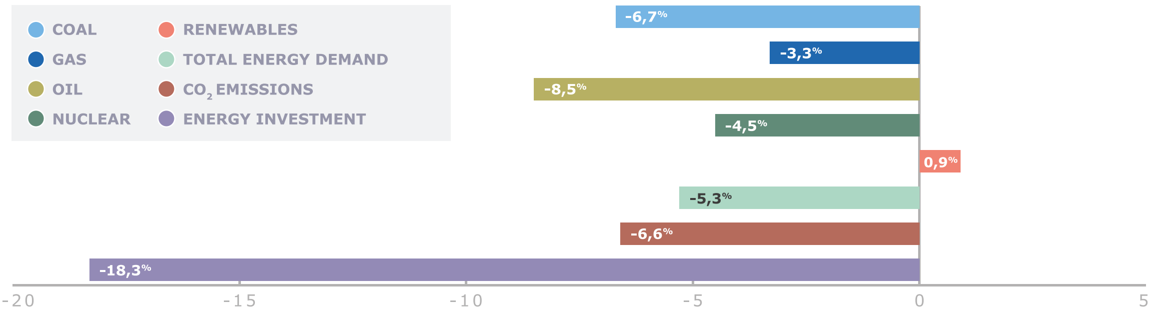
3 THE NEED FOR A CORPORATE STRATEGY RETHINK BECOMES APPARENT (ESPECIALLY IN OIL AND GAS)

COVID-19 HAS CONFIRMED SOME PROJECTED CHANGES TO THE ELECTRICITY INDUSTRY

	2020	FUTURE
COST STRUCTURE	MAINLY MARGINAL	MAINLY CAPITAL
GENERATION STRUCTURE	MAINLY CENTRALISED	MORE DECENTRALIZED
PRICES	BY KWH	?
PLANNING & OPERATION	FLEXIBLE SUPPLY TO ADAPT TO THE DEMAND	FLEXIBLE DEMAND TO MATCH SUPPLY
CONTROL & DISPATCH	FROM THE CENTRE	THROUGHOUT THE SYSTEM (INTERNET)
ROLE OF THE DEMAND	PASSIVE	INTERACTIVE
ROLE OF NETWORKS	NEUTRAL CONDUIT	SMART PLAYER

Source: KEAY, Malcolm & ROBINSON, David, *Glimpses of the future energy system? Demand flexibility and a proposal for a special auction*, OIES October 2020.

ENERGY DEMAND, CO_2 EMISSIONS AND INVESTMENT: 2020 COMPARED TO 2019, **RENEWABLE ENERGIES (*) ARE THE ONLY ONES FOR WHICH THERE IS A GROWING DEMAND**



Source: *World Energy Outlook 2020*, International Energy Agency. Release date: October 2020.
*The 0.9% increase in the demand for renewables amounts to an increase of over 6% for electric renewables and a reduction for other renewables.

Introduction

It is too early to know what the long-term impact of COVID-19[3] will be on the energy transition because we do not know how governments, companies and consumers will behave in a post-COVID world; nor do we know how long the pandemic will last. What we do know is that the impact of COVID-19 must be seen in the wider context of other global trends, including increased stress on the environment and encroachment on the natural world, social inequality, rising levels of debt and extreme poverty in emerging and developing countries, a retreat from globalisation and the deterioration of international cooperation.

What does COVID-19 mean for the hoped-for and expected energy transition, in particular decarbonisation of energy and end-use markets and greater energy efficiency? The pandemic has been devastating in many respects. Nonetheless, I will argue that COVID-19 has not diminished the pressures that were driving the energy transition before the pandemic and that some of these pressures – especially the financial ones – have grown stronger. (See section 'The energy transition was well underway before COVID-19').

Furthermore, in certain ways the pandemic has improved the prospects for the energy transition. First, COVID-19 offers lessons about what changes are needed to avoid future pandemics and other global crises, especially climate change. These lessons – in particular, the risks of disrespecting nature's boundaries and taking a short-term view – support the case for accelerating the energy transition. Other lessons relate to managing the energy transition, including the importance of addressing social concerns, promoting science and innovation and of government competence. (See section 'Lessons from COVID-19 that support the energy transition').

Second, the pandemic may also provide some glimpses into the likely future decarbonised energy system and some guidance on how energy companies and policy makers should prepare for it. (See section 'COVID-19: a glimpse of the future energy system?').

[3] COVID-19 is the disease caused by a new coronavirus called SARS-CoV-2. WHO first learned of this new virus on 31 December 2019, following a report of a cluster of cases of 'viral pneumonia' in Wuhan, People's Republic of China.

Third, the resulting economic crisis has provided the justification and the opportunity for governments to loosen their purse strings to stimulate a 'green' economic recovery that aims not only to help provide short-term economic relief but also to build for a sustainable future. Although governmental investments will be important, most of the investment will come from the private sector, which underlines the importance of policies that will encourage private investment. (See section 'Green recovery and the energy transition').

Fourth, the pandemic has accentuated other global problems – like trade barriers, international debt and extreme poverty – whose resolution requires international cooperation, which has been much diminished in recent years. Fortunately, the conditions and momentum now exist for a renewal of cooperation on the energy transition that is required to address climate change and related global problems. (See section 'International barriers to a global energy transition').

By way of conclusion, COVID-19 has in a number of respects improved the prospects for a global energy transition and provided a better understanding of how to proceed. However, it remains to be seen whether we will seize the opportunity. (See section 'Summary conclusions').

The energy transition was well underway before COVID-19

The International Renewable Energy Agency (IRENA) defines the energy transition as «a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. At its heart is the need to reduce energy-related CO2 emissions to limit climate change[4].» Another view is that the aim is for zero net carbon emissions, with any positive emissions being offset by negative emissions, e.g. by CO2 air capture and sequestration. Either way, the central objective of the energy transition is decarbonisation of the energy sector. This will involve a very significant penetration of renewable power, supplemented by decarbonised gases (e.g. 'green' hydrogen produced by electrolysis employing electricity generated by renewable sources). It will also require the electrification of many end-user markets that consume fossil fuels today, notably buildings, transport and industries, as well as improved energy effi-

[4] International Renewable Energy Agency, «Energy Transition». Consulted 24.12.2020

ciency throughout the economy. Indeed, the energy transition implies a change in the current overall social, political and economic paradigm, since energy is an input to almost everything, and the way it is produced and consumed affects the role of consumers, corporate strategy, competitiveness of an economy and much more. It is fair to say that global economic development and energy geopolitics have been 'path dependent'[5] on fossil fuels for over 100 years. The energy transition would put an end to this historic path.

Although fighting climate change is the primary policy driver behind the energy transition, it does not follow that the energy transition will be sufficiently fast or deep to 'solve' the climate crisis, if by that we mean meeting the ambition of the Paris Agreement to limit global warming (compared to the pre-industrial period) to well below 2ºC and if possible to 1.5ºC. Indeed, there is no compelling reason to be optimistic about meeting these targets. We are already seeing considerable global warming and its effects. Furthermore, there is a huge gap between the required emission reductions to reach the Paris targets and those that have occurred or are planned. The United Nations Environment Programme (UNEP) Emissions Gap Report 2019[6] estimated that a 7.6% reduction in greenhouse gas emissions every year between 2020 and 2030 could limit global warming to 1.5ºC. But the longer we wait, the more we will need to do later to avoid a climate disaster[7].

Climate change is not the only driver of the energy transition. Indeed, climate policy is an integral element of economic and trade policy. Other important drivers include gaining geopolitical advantage, industrial strategy, creation of employment, and growing support for reducing local environmental pollution.

The point is that, even during the pandemic and certainly after it, the energy transition is likely to continue and gather momentum for a variety of reasons explained below, even if it does not meet the Paris Agreement targets.

[5] Path dependence is when decisions are dependent on previous decisions or experiences in the past. Path Dependence exists when a feature of the economy is not based on current conditions, but rather has been formed by a sequence of past actions each leading to a distinct outcome. It is a reflection of institutional rigidity.

[6] United Nations Environment Programme 2020. Emissions Gap Report 2019. Consulted 22.12.2020.

[7] United Nations Environment Programme 2020. Emissions Gap Report 2020, p. 34. Consulted 22.12.2020.

Politics

Global Agreement

The Paris Agreement was a pivotal moment in the history of global climate change negotiations. Before the agreement, there was considerable doubt about the potential for any serious global commitment to fighting climate change. My own experience was that fossil fuel company executives were inclined to be resistant to acknowledging the need to cut carbon emissions, presumably because of the near-term threat to their own businesses from the energy transition. After the agreement, that changed. It was difficult for energy companies, investors and citizens to ignore the global political consensus in favour of the energy transition. Subsequently, President Trump slowed down the political momentum of the fight against the climate crisis, especially in the US and in countries, such as Brazil, that saw US withdrawal from the Paris Agreement as an opportunity to weaken their own ambition or indeed ignore the issue altogether. In spite of this setback, the political momentum behind the energy transition continued to grow before COVID-19 and indeed during the COVID-19 crisis, as witnessed especially with the growing number of countries committing to carbon neutrality[8].

National Commitments and Regional Agreements

In June 2019, the United Kingdom (UK) became the first major economy in the world to pass laws to end its contribution to global warming by 2050. The target will require the UK to bring all greenhouse gas (GHG) emissions to net zero by 2050, compared with the previous target of at least an 80% reduction from 1990 levels[9].

In December 2019, the European Commission presented its communication on the European Green Deal. It was described as a new growth strategy for the EU, aiming to transform it into a climate-neutral, fair and prosperous society, with a modern, resource-efficient and competitive economy. EU leaders reaffirmed their commitment to playing a leading role in the global

[8] Carbon neutrality is zero net emissions of CO_2. Climate neutrality refers to zero net emissions of all greenhouse gases, including CO_2, methane and other gases.

[9] Department for Business, Energy and Industrial Strategy. Gov.UK, «UK becomes first major economy to pass net zero emissions law», Gov.UK, 27 June 2019. Consulted 22.12.2020.

fight against climate change during the December 2019 meeting of the European Council, when they endorsed the objective of climate neutrality by 2050[10].

The number of countries adopting the objective of carbon neutrality grew during the COVID-19 crisis. By the end of 2020, more than 110 countries had pledged to reach carbon neutrality by 2050, and China had pledged to get there by 2060. By early 2021, countries representing more than 65 percent of global carbon dioxide emissions and more than 70 percent of the world economy had made commitments to carbon neutrality[11].

Sub-national Agreements

Political support around the world is also evident at the sub-national level. For instance, in the US, where President Trump did his best to promote fossil fuels and to discredit the Paris Agreement, there is a powerful movement to meet US commitments under that agreement, expressed through the «We are still in» Declaration. Since it was initially released in June 2017, over 3800 leaders at federal, state and local levels of government, corporations and colleges have signed the declaration. Together, they represent more than 155 million Americans and over $9 trillion of the US economy[12].

Local Governments for Sustainability (ICLEI[13]) is another example of sub-national commitment, in this case on a global scale. It is a network of more than 1750 local and regional governments – active in more than 100 countries – committed to sustainable urban development, and in particular to low emission, nature-based, equitable and circular development. Cities have become particularly important and active in the pursuit of decarbonisation, which reflects that a rising share of the global population lives in cities, and that emissions in cities are major contributors to climate change and to local pollution. It is noteworthy that a growing number of countries, states and cities around the world

[10] European Council, Council of the European Union, European Council Conclusions, 12-13 December 2019. Consulted 22.12.2020.

[11] The race to zero emissions, and why the world depends on it, United Nations, 2 December 2020. Consulted February 15, 2021.

[12] «We Are Still In» Declaration. Consulted 22.12.2020.

[13] Local Governments for Sustainability, ICLEI. Official ICLEI website. Consulted 04.01.2021.

are phasing out or restricting the use of internal combustion engine (ICE) vehicles[14].

Technology and economics

The political momentum and support for the energy transition has grown along with the decline in the anticipated costs of that transition, in particular the falling costs of solar photovoltaics (PV), wind power, electric vehicles (EV) and batteries. In fact, the two are related. For instance, the political (and public financial) support for renewable energy, especially in Germany, led to growing demand for solar PV and wind turbines. In response, China was able to significantly reduce the cost of these technologies, largely due to their ability to take advantage of scale and learning economies. Today, these technologies are available throughout the world at prices that have fallen steadily and steeply since 2010, as illustrated by Figure 1.

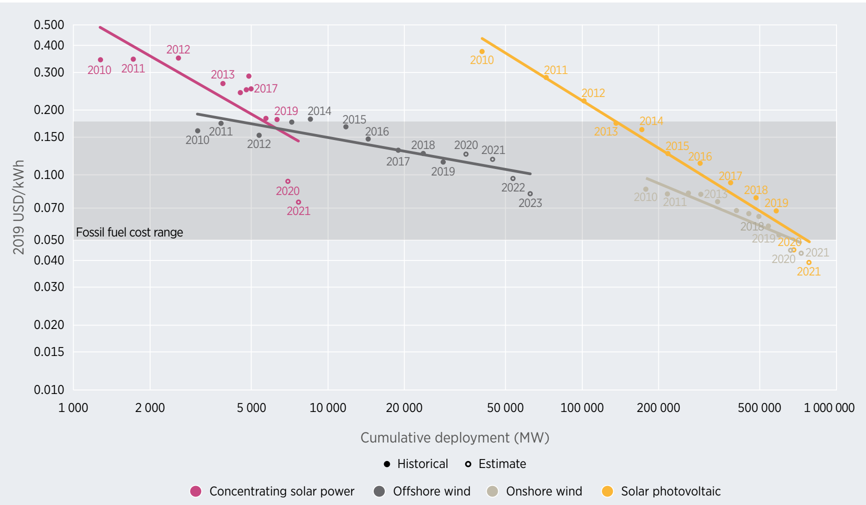


Figure 1. Global weighted-average LCOE and Auction/PPA Price learning curve for solar PV, CSP, onshore and offshore wind, 2010-2021/23 Source: IRENA Renewable Power Generation Costs Report 2019, International Renewable Energy Agency, 2020.

[14] WAPPELHORST, Sandra & CUI, Hongyang, «The countries and states leading the phase out of fossil fuel cars», The Driven, 12 November 2020. Consulted 22.01.2021. BENDIX, Aria, «15 major cities around the world that are starting to ban cars», Business Insider, 12 January 2019. Consulted 22.01.2021.

Apart from the declining cost and price of renewables, digital software has enabled the growth of distributed energy resources (DER), which increase competition in energy markets and provide flexibility to integrate renewables and reduce the cost of decarbonisation. This does not mean that decarbonisation is costless. Replacing fossil fuels with decarbonised energies involves major new investments. Furthermore, existing assets producing or consuming fossil fuels lose value (assets are 'stranded') as a result of decarbonisation, with important costs for the 'losers' – the affected companies, employees and communities. Nevertheless, as the incremental costs of new technologies fall, the resistance to the energy transition diminishes, especially when measures are taken to compensate and support the 'losers'.

Financial regulatory and market pressure

Well before COVID-19, financial regulators and private financial markets had already demonstrated their concerns about climate-related financial risks and their growing support for decarbonised energy sources. There was also a recognition that global investment requirements for the energy transition were on the order of $2-3 trillion per annum, over 2% of global Gross Domestic Product (GDP), significantly more than historic investment in the energy sector. This would also require a major reallocation of private capital flows towards 'green' activities.

In 2015, when he was the Governor of the Bank of England, Mark Carney made a speech on climate change at Lloyds of London[15]. He warned that climate change would lead to financial crises and falling living standards unless the world's leading countries did more to ensure that their companies come clean about their current and future carbon emissions. He referred to climate change as the *Tragedy of the Horizon*. «We don't need an army of actuaries to tell us that the catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors - imposing a cost on future generations that the current generation has no direct incentive to fix.» He was referring to changes beyond the traditional time horizons of the business cycle, the political cycle, and technocratic authorities, like central banks, who are bound

[15] Speech by Mr Mark Carney, Governor of the Bank of England and Chairman of the Financial Stability Board, at Lloyd's of London 29 September 2015. Consulted 06.05.2021.

by their mandates. He said the outer boundaries of the horizon were about a decade.

He pointed to three kinds of risk:

- First, *physical risks*: the impacts today on insurance liabilities and the value of physical assets that arise from climate- and weather-related events.
- Second, *liability risks*: the impacts that could arise tomorrow if parties who have suffered loss or damage from the effects of climate change seek compensation from those they hold responsible.
- Finally, *transition risks*: the financial risks which could result from the process of adjustment towards a lower-carbon economy. Changes in policy, technology and physical risks could prompt a reassessment of the value of a large range of assets as costs and opportunities become apparent.

Perhaps the most important document on global 'green' financial policy following the Carney speech was prepared by the Task Force on Climate-Related Financial Risk Disclosures (TCFD). The final conclusions were published in 2017. In the letter introducing the report[16] to the Financial Stability Board of the Bank for International Settlements, on behalf of the Task Force, Michael Bloomberg writes:

The Task Force's report establishes recommendations for disclosing clear, comparable and consistent information about the risks and opportunities presented by climate change. Their widespread adoption will ensure that the effects of climate change become routinely considered in business and investment decisions. Adoption of these recommendations will also help companies better demonstrate responsibility and foresight in their consideration of climate issues. That will lead to smarter, more efficient allocation of capital, and help smooth the transition to a more sustainable, low-carbon economy.

No doubt partly in response to the TCFD proposals, the EU, among other governments, has been actively promoting greater disclosure of climate-related financial risks and more generally sustainable finance. In 2018, the EU published its Action Plan: Financing

[16] TCFD, «Recommendations of the Task Force on Climate-related Financial Disclosures», Final Report, June 2017. Consulted 12.01.2021.

Sustainable Growth[17], which outlined a number of measures that influence both the EU's own financing decisions and decisions by the private sector. These measures aimed to:

- reorient capital flows towards sustainable investment in order to achieve sustainable and inclusive growth;
- manage financial risks stemming from climate change, resource depletion, environmental degradation and social issues; and
- foster transparency and long-termism in financial and economic activity.

The EU has built on this action plan and adopted a taxonomy to guide and encourage investment in sustainable businesses[18].

The pressure from financial regulators has continued to grow during the pandemic, with the US Fed announcing in December 2020 that it had formally joined the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), as a Member. At that time, the NGFS had 83 Members and 13 Observers[19].

In parallel, private banks have been committing to support decarbonisation. For instance, the UNEP FI project (Finance Initiative of the United Nations Environment Programme) includes 38 banks from across all six continents who have committed to align their loan portfolios (i.e., to finance businesses committed to the environment) with the global climate goal to limit warming to well-below two degrees, striving for 1.5ºC[20].

Investment

The financial regulatory pressure, along with political and economic evidence that decarbonisation was becoming economically more attractive, had an impact on private investment decisions in the energy sector well before COVID-19. For instance, according to

[17] European Commission, «Action Plan: Financing Sustainable Growth», Document 52018DC0097, Brussels, 8 March 2018. Consulted 06.01.2021.

[18] Helena Viñes Fiestas, «Post-COVID-19 green recovery through the lens of an investor», Oxford Energy Forum 123, July 2020. Consulted 14.01.2021.

[19] Membership of the NGFS- Network of Central Banks and Supervisors for Greening the Financial System as of 14 December 2020. Consulted 08.01.2021.

[20] GASCUEÑA, Dory, «38 banks against climate change: what are they achieving?», BBVA, 10 December 2020. Consulted 08.01.2021.

Bloomberg New Energy Finance (BNEF)[21], nearly 78% of new generation capacity added globally in 2019 was in wind, solar, biomass and waste, geothermal and small hydro. Investment in renewables, excluding large hydro, was more than three times that of new fossil fuel plants. This brought the share of renewables in global generation to 13.4 percent, up from 12.4% in 2018 and 5.9% in 2009. In the transport sector, sales of electric vehicles rose to 2.1 million globally in 2018, a 40% year-on-year increase, albeit on a small base relative to total vehicle sales. It is certainly true that the increased investment in renewables and EVs reflected policy support. Nevertheless, it also reflected investor confidence in the future of decarbonised energy and 'green' industries and diminishing confidence in the prospects for fossil-fuel based companies and the industries that relied on fossil fuels.

In spite of the economic crisis, the investment trend towards green energy appears to have continued during the pandemic, both on the stock market and in direct investment in certain assets, especially renewable power. For example, Tesla's share value rose by 700% over 2020, making Elon Musk the wealthiest man in the world, with Tesla worth more than the nine largest automobile manufacturers[22]. The rising value of Tesla also reflects the view that the company is actually investing in a decarbonised energy system, including EV's, rooftop solar panels and the Powerwall battery. Other stock market examples are the rising share values of electricity companies that have strongly committed themselves to renewables (Enel, Iberdrola, Orsted)[23] and the falling value of oil stocks[24].

One reflection of the energy transition is the declining global investment in fossil fuels since 2014 compared to the steady investment levels in electricity. It is worth stressing that costs of renewable power have fallen substantially, so generation capacity additions can rise when investment amounts are steady or even potentially when they fall.

21 Bloomberg New Energy Finance, «Falling Clean Energy Costs Can Provide Opportunity to Boost Climate Action in COVID-19 Recovery Packages», 10 June 2020. Consulted 05.01.2021.

22 KOLODNY, Lora & WAYLAND, Michael, «Tesla's market cap tops the 9 largest automakers combined- Experts disagree about if it can last», CNBC 14 December 2020. Consulted: 08.01.2021.

23 ADEEB, Maryam, «Top 20 European utilities gain €74.1B market value in Q3», S&P Global, 14 October 2020. Consulted 08.01.2021.

24 HUME, Neil & RAVAL, Anjli, «European oil stocks dealt €360bn blow white renewables surge», Financial Times, 29 October 2020. Consulted 08.01.2021.

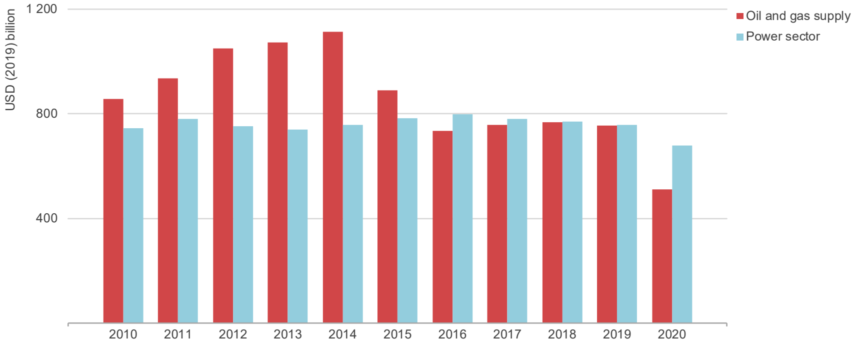


Figure 2. Global investment in energy supply. Source: World Energy Investment 2020, Overview and Key Findings, International Energy Agency.

Because Figure 2 includes fossil fuel investments in power, it hides the continuing strength of investment in renewable power during the COVID-19 pandemic. In November 2020, the IEA's main case scenario was that renewable electricity capacity additions would be almost 4% higher in 2020 than in 2019. They expected renewables to account for almost 90% of additional capacity. This was in spite of a very slow start to the year.

Supply chain disruptions and construction delays slowed the progress of renewable energy projects in the first six months of 2020. However, construction activity did not halt in many countries even during full/partial lockdowns, manufacturing activity has ramped up quickly, and logistical challenges have been mostly resolved with the easing of cross-border restrictions since mid-May. Monthly capacity additions through September have exceeded previous expectations, pointing to a faster recovery in Europe, the United States and China. As a result, the forecast for 2020 has been revised upwards by over 18% from our previous update in May[25]*.*

Figure 3 illustrates the IEA's forecast of investment growth in renewables in 2020 and 2021, well ahead of forecasts they made for both years in May 2020 (the yellow dots).

While the investment signals increasingly favour the transition away from hydrocarbons, the penetration of decarbonised energy

25 International Energy Agency, Renewables 2020 Analysis and forecast to 2025, November 2020. Consulted 23.01.2021.

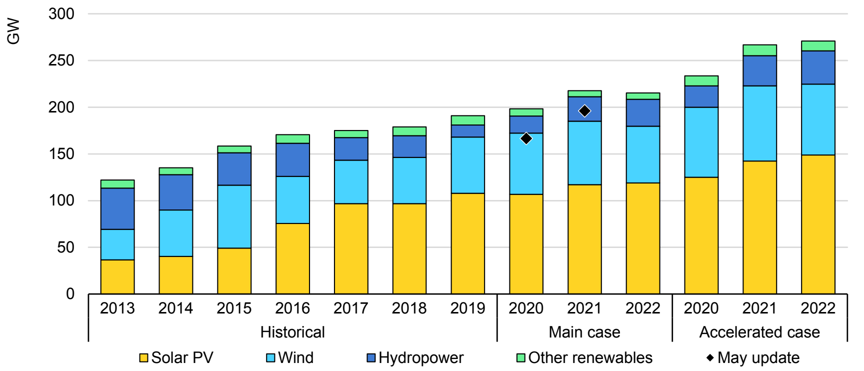


Figure 3. Renewable electricity net capacity additions by technology, main and accelerated cases, 2013-22.
Source: Renewables 2020: Analysis and Forecast to 2025, International Energy Agency, November 2020.

is still very low. Fast growth rates reflect the low bases. Over 80% of energy continues to be from fossil fuels. Even the power sector which was decarbonising most rapidly continues to rely heavily on fossil fuels, in particular coal, as illustrated by this BNEF graph below (Figure 4). However, this graph also illustrates the expectation, which was widely shared before COVID-19, for much deeper decarbonisation of the power sector from 2020-2050.

Before COVID-19, the oil companies were already predicting a significant decline in the role of oil, gas and especially coal, along

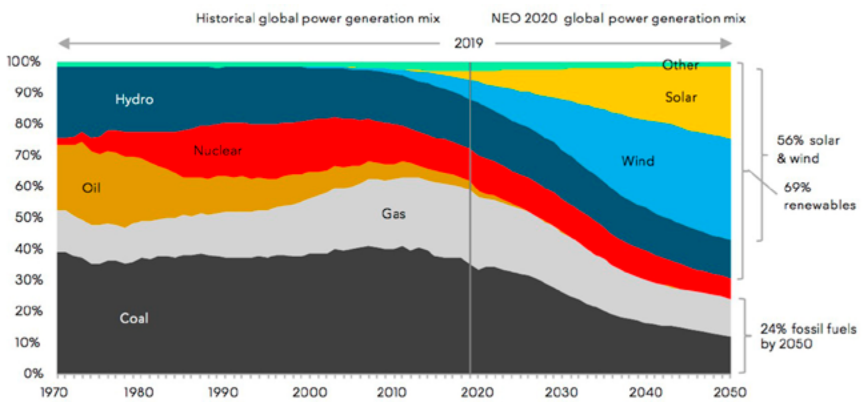


Figure 4. Global electricity generation mix
Source: Bloomberg New Energy Outlook 2020, p8, Bloomberg NEF.

with rising renewables and electrification, but they expected a smooth transition that would give them time to adapt. In 2017, the CEO of Shell said that his next car would be electric, and he predicted that electricity's share of energy demand would rise from 20% in 2019 to about 50% in 2050. In 2020, BP published its own Energy Outlook[26], which included three scenarios that all reflected the declining share of hydrocarbons and the rise of renewables over the period to 2050. In one of the scenarios (Net Zero), its projection was that renewables would account for 60% of primary energy and hydrocarbons for 20% in 2050.

Civil society

Partly because of clear evidence of a changing climate, we have seen growing citizen awareness and perception of climate change as a reality, as well as evidence of the energy transition gaining momentum.

Special mention of Greta Thunberg is important, not just because she has galvanised support for action to fight climate change, especially among the young, but because she is perceived by the fossil fuel community as a 'tsunami'. The term used by some in that community reflects both the power of the wave and perhaps their hope that the wave will recede.

It is interesting to note a move to involve citizens directly in policy making (or thinking) through Citizen Assemblies. Between 2016 and 2018, Ireland held a number of these assemblies to address difficult policy issues, including same-sex marriage, abortion and climate change. The assemblies there were designed to feed ideas directly into the existing political process rather than to replace it. A number of countries, including the UK and France, have adopted similar assemblies to engage citizens in decisions about the energy transition and climate change, and others, including Spain, are planning to do so[27].

Resistance weakening

Prior to COVID-19, there remained strong resistance to decarbonisation from part of the fossil fuel community, especially the

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[26] BP Energy Outlook 2020.Consulted 28.12.2020.

[27] FARAND, Chloé, «Citizen's assemblies on climate change seek to shape the post-Covid recovery», Climate Home News, 17 April 2020. Consulted 08.01.2021.

US-based oil, gas and coal companies and from countries that are either major exporters of fossil fuels or see fossil fuels as their best bet for economic development.

However, the resistance to the energy transition was weakening well before COVID-19 and has weakened further during the pandemic. For fossil fuel companies, this was mainly because the economic, political, financial, legal and social conditions were forcing the fossil-fuel companies to disclose their climate-related financial risks and because these companies were increasingly aware that they needed to decarbonize. In 2019, a number of oil and gas companies, mainly European (Shell, Total, BP), had already announced plans to reduce their emissions and shift investment to electricity, and at least one (Repsol) had announced plans to be a net-zero emissions company by 2050[28]. During the pandemic, Exxon announced a new five-year plan to reduce greenhouse gas emissions, including from methane flaring and upstream operations, which it said were in line with the Paris Agreement reduction targets[29].

In developing countries, financial and political support from China to build carbon-intensive infrastructure through the Belt and Road Initiative (BRI) resulted in coal-fired plants being built in many developing countries. However, even before COVID-19, the Chinese BRI was running into trouble[30]. For example, lending by the China Development Bank and the Export-Import Bank of China is reported to have collapsed from a peak of $75bn in 2016 to just $4bn in 2019. The main reasons for this appear to be that recipients of the loans were unable to pay their debts and that there was international criticism of the BRI for lack of transparency or social and environmental impact studies.

Resistance to decarbonisation also comes from countries whose economies and security depend on fossil fuels. These include major exporters of fossil fuels (e.g. Middle East, Russia) as well as countries which rely on domestic fossil fuels and are concerned that decarbonisation means rising energy costs and weakened security (e.g. China, Poland, India). But all of these countries are

[28] Repsol será compañía cero emisiones netas en 2050, Repsol Strategic Plan 2021-25. Consulted 29.12.2020.

[29] ROSENBAUM, Eric, «Oil giant Exxon Mobil pushes new climate change plan as activist investors circle», CNBC, 14 December 2020. Consulted 08.01.2021.

[30] WHEATLEY, Jonathan & KYNGE, James, «China curtails overseas lending in face of geopolitical backlash», Financial Times, 8 December 2020. Consulted 10.12.2020.

aware that decarbonisation is now inevitable, even if they would like to slow it down.

Key Messages

The first message is that energy transition was already underway and gaining momentum before COVID-19, in response to growing pressures. The second is that, from this overview, these pressures continued to exert influence during the pandemic, and that some of them intensified further, especially from the financial sector. Indeed, growing investment in renewables during the pandemic is evidence of the particular strength of this part of the energy transition. However, fossil fuels continued to supply over 80% of world energy supplies and most forecasts assumed that fossil fuel demand would only begin to peak after 2030. The remainder of this chapter argues that the pandemic has created the conditions for an acceleration of the energy transition.

Lessons from COVID-19 that support the energy transition

COVID-19 has revealed a number of policies and human behaviours that have contributed to the pandemic and that need to change in order to avoid future pandemics and other global crises, in particular accelerated climate change, ocean degradation and loss of biodiversity. These lessons reinforce the case for the energy transition and offer some guidance on the respective roles of government and civil society.

The change we need

Respect for the natural world

The pandemic should be a wake-up call about the consequences of human disrespect for the natural world. A World Wildlife Fund report[31] explains how this disrespect (or encroachment) has caused wildlife populations to plunge over five decades and signals a broken relationship with nature that helped trigger the global coronavirus pandemic. In their view, the coronavirus pandemic was caused by the sort of «spillover» of a zoonotic virus that is becoming more common as humans expand their foot-

[31] «Living Planet Report 2020- Bending the curve of biodiversity loss», 2020, World Wildlife Fund. Consulted 11.01.2021.

print: it should be viewed as «an SOS signal for the human enterprise»[32]. In response to that signal, the energy transition is an important move in the right direction, towards greater respect for the natural world.

A long-term view and the precautionary principle

A second and related problem is that key decisions, especially policy and investment decisions, are taken with a relatively short-term time horizon. As mentioned in the last section, Mark Carney has argued that this leads to the tragedy of the horizon: the impacts of our decisions are evident well beyond the period that most actors consider. These decisions impose costs on future generations that the current generation has no direct incentive to fix until it is too late. The response to this tragedy should be to demand of ourselves, policy makers and investors a much longer-term view of the consequences of our decisions, and to apply the precautionary principle when there is a material probability of contributing to environmental or human catastrophe. A successful energy transition is consistent with taking a longer-term view and policies should be designed precisely with this guidance in mind.

Early action to stop a crisis from becoming uncontrollable

Although a long-term view is required to avoid a crisis, COVID-19 illustrates the consequences of acting too late when a crisis arrives. Those countries that moved swiftly to stop the pandemic were able to control it and to return to relative normality quickly. Those that did not move swiftly found themselves with problems of increasing intensity, leading to increasingly severe policy responses which some cultures (especially in the US) resist. This seems exactly analogous to the harsh cutbacks in emissions that will now be required to meet emission reduction goals because the world did not act earlier. The slower we move on the energy transition, the greater will be the intensity of the climate change problem, the severity of measures to manage it and the potential for serious political, economic and social consequences.

32 BRULLIARD, Karin, «Humans are decimating wildlife, and the pandemic is a sign, report says», The Washington Post, 10 September 2020. Consulted 08.01.2021.

Global cooperation to deliver global public goods

Global pandemics are like climate change and nuclear proliferation. They have the potential to impact the lives of everyone because their effects cross borders. Dealing with pandemics and other global crises requires international cooperation. By contrast, the responses to COVID-19 have mainly been national or regional, as if the pandemic and its effects could be stopped from crossing borders. Furthermore, COVID-19 has accentuated health disparities within and between countries, regions and continents, with the global scramble for vaccines being a sad example. The lesson is that global cooperation is required to avoid crises and to deal with them when they occur. The energy transition has the potential to contribute to the global public good of a safe environment. For it to do so will require global collective action, including policies to address the negative consequences of the energy transition, with 'fair transition' plans that apply both domestically and internationally.

Support for science and innovation

2020 has confirmed the importance of science and innovation. On the one hand, the chaotic initial response to the virus revealed the failure of the funding of scientific research prior to the pandemic, and more generally the failure of preparation, especially in western nations. This was in spite of warnings from scientists and others about the growing likelihood of global pandemics. On the other hand, the rapid analysis of the underlying genome of the virus and the successful development of effective vaccines in record time are undeniable evidence of the role that science can play in making the world a safer place for all. Indeed, science has been an example of outstanding international cooperation during the pandemic. In the words of the European Parliament:

> *Despite rising geopolitical tensions, the pandemic has thus opened a window of opportunity for reinforced scientific cooperation and a global approach to health. Not only has the pandemic spurred a sense of urgency for such a global scientific approach but also do today's technologies today allow for it – which for instance was not the case during the HIV epidemic in the 1980s and 1990s. This need has been acknowledged by leaders across the globe; for instance at a UNESCO meeting with representatives of ministries in*

> *charge of sciences in 122 countries as well as the EU, the African Union, and the WHO*[33].

This has implications for the energy transition:

- First, it is a reminder of the importance of listening to the scientific evidence when making political decisions. Given the overwhelming scientific consensus that decarbonisation is key to fighting climate change and that the remaining carbon budget is very limited, the case for a rapid energy transition is increasingly clear.
- Second, the failure to fund research prior to COVID-19 is a cautionary tale. RD&D is essential to develop the necessary technologies and services to mitigate climate change and to adapt to it. This is not simply a matter of political decisions, although public funding for basic research is economically justified due the potential welfare benefits that would not be realised if all research were to be privately funded. It is also about creating the right political context, financial markets and other institutions to fund RD&D and to bring new zero-carbon technologies to market.
- Third, COVID-19 is an illustration of the enormous cost of not being prepared for something that is inevitable. There was sufficient evidence from the scientific community that a pandemic was inevitable to warrant dedicating the necessary resources to being prepared for it[34]. The failure to plan was, as they say, a plan to fail. The costs of being unprepared for the inevitable are counted in human lives and suffering as well as in the enormous economic disruption caused. The consequences of not being prepared for climate change are far greater.
- Fourth, the pandemic, and the incredible science-based response to it, have (I hope) augmented people's trust in science, even if they don't know anything about gene sequencing, bioengineering or other contributors to understanding and now responding to the threat of the novel coronavirus. Any such increase in people's confidence in biological science may

[33] European Parliament, Policy Department for External Relations, «The Geopolitical Implications of the COVID-19 pandemic», p35, September 2020. Consulted 28.12.2020.

[34] MARANTZ HENIG, Robin, «Experts warned of a pandemic decades ago. Why weren't we ready?», National Geographic, 8 April 2020. Consulted 29.12.2020.

carry over into other areas of science, notably climate science, another area where the general population has no real understanding and where interested parties (coal, oil, gas and other profit-seeking entities) have stoked considerable scepticism about climate change (causes and consequences) in that general population.

Increasing citizen awareness of the case for change

COVID-19 generally confirms that we are able and willing to change the way we live and behave, when 'necessary'. However, for most of us, the experience is very unwelcome, in particular being confined to our homes, wearing masks, social distancing, and not visiting friends and family. We would not want this to be a permanent and forced change in lifestyle. This experience should serve to make citizens more aware of the risks to our lives associated with irreversible deterioration of the environment.

On the other hand, COVID-19 has rewarded citizens with the return of blue skies, birdsong and relative quiet, especially in urban areas[35]. David Attenborough was especially pleased not to hear the sound of airplanes landing every 30 seconds over his house in London. No one expects the world to remain this way once the worst of COVID-19 is in our rear-view mirror. But it is surely reasonable to expect people to be more sensitive to the value of the environment and to do more to protect the basic pleasures it offers.

The COVID-19 experience has contributed positively to our social lives in other ways: understanding the potential for technology to connect us, allowing some to work from home[36], recovering and visiting rural areas as we travel within our confined national or regional spaces, and creating a sense of community[37] and solidarity with those who are hardest hit by the pandemic, and with those who have been so critical to surviving the pandemic.

[35] European Parliament, Policy Department for External Relations, «The Geopolitical Implications of the COVID-19 pandemic», p40, September 2020. Consulted 28.12.2020.
[36] BAILEY, Joel & NEUFELD, Peter, EY, «How is COVID-19 continuing to change human behaviour and affect our ways of living and working?», 18 June 2020. Consulted 27.12.2020.
[37] BRADSHAW, Alan, World Economic Forum, «How is COVID-19 affecting our day-to-day behaviour?», 14 October 2020. Consulted 19.12.2020.

In short, increased citizen awareness should contribute to an understanding of the potential benefits of the energy transition and the costs of being forced to change lifestyles in response to environmental and other crises that will be beyond our control if we do not act to contain them in time.

The role of government and civil society in shaping the energy transition

These lessons from COVID-19 offer some high-level guidance on how to shape the energy transition, in particular on the roles of government and civil society.

Government competence is key

Some governments were well prepared, acted swiftly and effectively to stop the virus from spreading, and managed well the economic and social consequences. Others were totally unprepared, very slow to react and ineffective in their management. A successful energy transition requires competent governments, whatever their political stripe.

Governments need to address social concerns

COVID-19 is both revealing and increasing inequality and poverty within countries and among them; climate change would do the same, and the energy transition entails the same risk. In pursuing the energy transition, governments need to manage the social impacts carefully and think through their policies with them in mind, including the introduction of 'fair transition' mechanisms to support those most in need. COVID-19 experience also suggests that people are prepared to accept even quite harsh measures, at least temporarily, provided that they are confident that the measures are necessary and fair, that there is a coherent strategy, and that there is light at the end of the tunnel. In a situation with radical uncertainties, but a need to take strong policy measures, the best way to maintain public trust is to operate transparently and keep the messaging clear and straightforward.

Governments must work with business and civil society

Governments in the world's largest economies are responding to COVID-19 with stimulus packages to aid the economic recovery, drawing on fiscal and monetary resources. There is widespread support for governments playing this role. If the funds are channelled effectively, this is undoubtedly good news. Nevertheless, government control over the key investment decisions raises the risk of major and expensive policy mistakes that are paid for by today's taxpayers and consumers and ultimately future generations. Planning has to be as robust as possible to minimize the risk of mistakes, especially in the use of public funds. It is important to ensure that those funds are channelled effectively and that they do not restrict innovation or impose unnecessary barriers to international trade and investment. This will require governments at all levels and in most countries to cooperate and to work closely with investors and citizens.

Key Messages

Lessons from COVID-19 support the energy transition and offer guidance on how to make the transition effective. In support of the energy transition, the pandemic is a cautionary tale that should remind us of the importance of respecting nature's limits, thinking long-term, taking early action and adopting the precautionary principle. In terms of making the energy transition effective, we should be more aware now of the importance of global cooperation, science and innovation and the critical role of competent governments, especially in addressing social concerns and in working with civil society and private investors.

COVID-19: a glimpse of the future energy system?[38]

The question mark in the title to this section is intentional. It is not possible to say for certain what the impact of COVID-19 will be for the energy transition. Many of the changes during COVID-19, especially in energy demand, may be reversed when the pandemic is over. However, the first part of this section identifies a number of features of the energy scene during COVID-19 which seem consistent with forecasts for the longer term in many climate scenarios. The second part looks in more detail at some early glimpses of a future decarbonized electricity sector and their possible implications for policy and strategy. The third part

[38] This section draws on KEAY, Malcolm & ROBINSON, David, «COVID-19: Glimpses of the energy future?» Oxford Institute for Energy Studies, July 2020. Consulted, 24.01.2021.

indicates what sorts of change could be in the cards in relation to oil and gas and what they might imply for industry strategies and business models.

Early glimpses of the future energy sector?

During the COVID-19 epidemic, the world has witnessed changes which are consistent with developments that have been widely forecast for 2030 and beyond. Some of the changes are reflected in Figure 5, which is the IEA's forecasts for 2020, as of November of that year.

Global energy demand will fall by almost 6%, roughly equivalent to the increase of the last five years. Of that, coal demand will fall by about 7%, and oil demand by almost 9%, equivalent to almost a decade of growth[39].

Renewables are the only energy source with rising demand. The IEA forecast a rise of 1% in demand for renewables. This demand figure is the net result of an increase of more than 6% in the

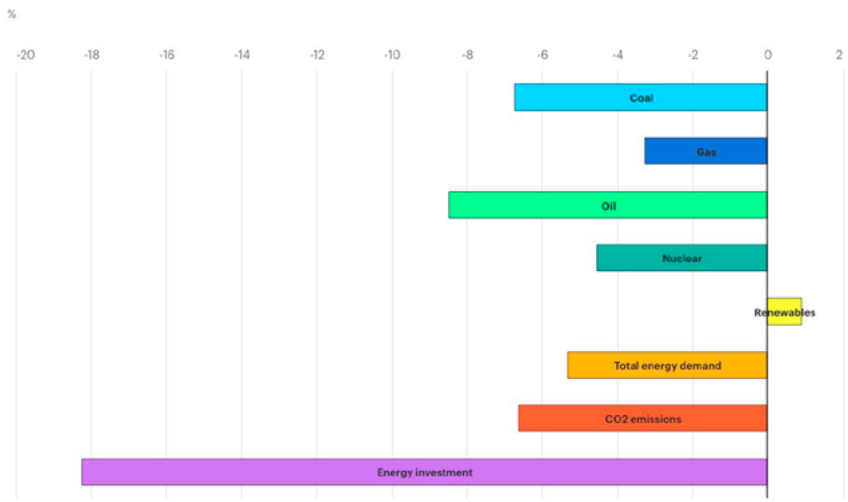

Figure 5: Key estimated energy demand, CO2 emissions and investment indicators, 2020 relative to 2019
Source: World Energy Outlook 2020, International Energy Agency. Release date: October 2020.

39 SMITH, Grant, «Oil Nations' Summer of Strife Offers Glimpse of Pain to Come», Bloomberg, 12 August 2020. Consulted: 05.01.2021.

demand for renewable electricity and a decline in the demand for other renewables (e.g. biofuels for transport).

Although global investment in energy is expected to fall by almost 20% in 2020, this is not a glimpse of the future. Investment in energy will rise very substantially in future. However, COVID-19 did illustrate how investment would shift, namely towards renewables and electricity and away from fossil fuels. As illustrated earlier in Figure 3, investment in additional renewables generation capacity increased in 2020 by over 4% compared to 2019.

Global emissions fell by almost 7%, mainly due to declining demand and also due to a rising share of renewable energy. Declining global energy demand is not consistent with most predictions, but the rising share of renewables certainly is.

Electricity

Beyond the changes in overall energy demand and investment, there were a few glimpses of special relevance for the power sector.

- A shift towards electricity, especially residential use. Electricity demand has fallen by much less than demand for other energies, due to increasing residential electricity consumption, matching a shift seen in many decarbonisation scenarios (although most previous scenarios expect this shift due to the expected electrification of transport and heating, not to people being confined at home).
- Absorbing renewables has presented major challenges. Rising renewable output and lower demand have caused problems for many systems.
- Falling and negative wholesale electricity prices coincide with rising final tariffs. Lower demand and rising renewable output is driving wholesale prices down, while negative prices have become more common as generators have to be paid to reduce output in the face of low and inflexible demand. In a small number of cases, consumers have been able to benefit from these negative wholesale prices. More commonly, final tariffs (per unit consumed) are rising or will rise to recover fixed costs from lower throughput, renewable subsidies that rose with higher renewable output and higher balancing charges. Rising tariffs per unit of output could be consistent with falling

bills if total consumption is falling. But during the pandemic, residential consumption has been rising due to confinement and home working.
- Digitalisation and the role of electricity. Confinement at home has significantly increased consumer use of the internet for home working, shopping online and communications. The accelerated digitalisation of society is consistent with an increase in the potential for more active consumer participation in the power sector.

By way of illustration, here is a short summary of some of the changes witnessed in the UK electricity sector during 2020.

- Increased generation from intermittent renewables, especially wind and solar PV. At times intermittent renewables as a whole have reached 60% or more of generation: during the weekend of 23/24 May renewable generation in the UK amounted to 73% of the total. On December 26, Great Britain reached a new, green milestone when wind turbines generated more than half of its total electricity.
- Growing decentralization. Generation from decentralised sources has grown – for instance, output of solar power (mainly decentralised) at its peak on 20 April 2020 met around 30% of UK demand, a record.
- Falling carbon intensity. This reached the lowest level recorded, at 46g/kWh - well below the target for 2030 and a reduction of over 90% compared with the 1990 baseline. Changes on the supply side are capable of meeting even very ambitious carbon targets.
- Increased volatility in generation. For instance, during the week commencing 4 May, wind averaged 9.2% of the generation mix for the first six days of the week before jumping to 41% on 10 May. This creates a need for flexibility.
- Rising element of fixed costs and falling flexibility. With the still significant nuclear component and rising renewable output, the dominant element in the cost structure of generation was capital, rather than marginal cost, and the flexibility of generation has diminished substantially.
- Increasing cost of balancing. The penetration of intermittent renewables requires flexible resources to balance supply and demand. As the share of renewables rose during COVID-19, so did the cost of balancing the system. Whereas balancing costs were about 10% of generation costs in 2019, they rose to over 20% in the first half of 2020 (Figure 6).

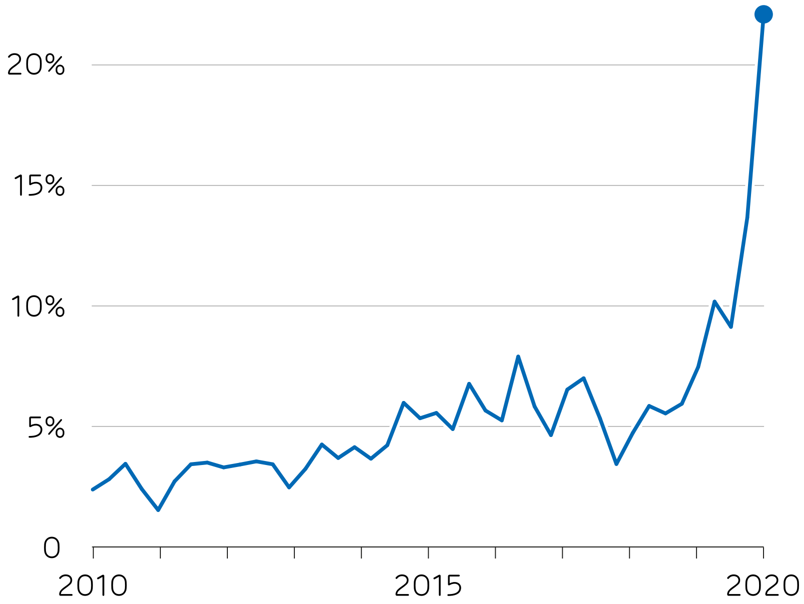

Figure 6: Great Britain electricity system balancing cost as share of generation cost
Source – Drax Electric Insights: Q2_Report, p9.

In short – in line with expectations for the future – the UK system has become much less carbon intensive, but it has also had to adapt much more rapidly and flexibly than in the past and without the tools it used to rely on.

Experience during COVID-19 has thus witnessed new patterns of energy demand and supply in line with those that have been widely predicted for a more distant future. It may prove helpful that the future has arrived more quickly than expected (even if only on a temporary basis). In the process, we may be able to learn some practical lessons which, while consistent with the general trends above, were not necessarily obvious in advance. For instance, here are some possible lessons for the future from the UK.

- Role of nuclear. Many industry observers have seen decarbonisation as paving the way for a nuclear renaissance, arguing that no other source can provide large quantities of secure, carbon-free 'baseload' power. But experience in 2020 suggests that nuclear may not be such a good 'fit' in a decarbonised system – the concept of 'baseload' is getting less relevant and large quantities of inflexible generation are proving more of a problem than a solution in a renewables dominated system. An agreement reached this spring between the UK Electricity System Operator (UKESO) and EDF Energy to reduce output from the 1.2GW Sizewell B nuclear power station was one illustration of the problem. If nuclear is to have a role in the low carbon future it may have to be by providing flexibility, rather than baseload power. Indeed, in France, this seems to be happening already – the head of the French system operator described the company as being 'permanent acrobats' in a new sport[40]. The design and operation of any new nuclear plants may need to be based on their acrobatic abilities.

- Role of the demand side. Although overall energy demand has seen the big shifts described above, electricity demand has in fact changed relatively little (at least in terms of the scale of the changes needed to make a significant contribution to decarbonisation) and its role may need to be rethought. Traditionally, the demand side has been seen as passive and the main policy focus has been on energy efficiency. Even in relation to 'demand response' most attention has been on shifting consumption away from times of peak demand. But recent experience has created a new focus on peak supply and the need to find efficient ways of increasing demand to match it (e.g. by filling storage). However, the instruments for doing so remain rudimentary – negative wholesale prices rarely get through to consumers. They have been supplemented by ad hoc instruments like the UKESO's Optional Downward Flexibility Management (ODFM) service to encourage large users and generators to increase demand or reduce generation respectively during low demand periods, but these remain marginal elements. In the longer term, as an article by Keay and Robinson argues, more fundamental market reforms will be needed to encourage active consumer participation and they have proposed a new 'two market' approach[41] for this purpose.
- Platforms. The old model of electricity supply was straightforward – electricity flowed from a central generating unit, through transmission and distribution systems, to the consumer. Now the picture is much more complicated. Not only are consumers increasingly active participants via flexible de-

[40] https://www.web24.news/u/2020/04/containment-drops-electricity-consumption-by-20-in-france.html. Consulted 09-04.2020.

[41] KEAY, Malcolm & ROBINSON, David, «The Decarbonised Electricity System of the Future: The 'Two Market' Approach», The Oxford Institute for Energy Studies, June 2017, University of Oxford. Consulted 07.01.2021.

mand, they may also be producers themselves (e.g. via rooftop solar panels) and their demand patterns may be more complex (e.g. for Electric Vehicles – EVs) while more real time information about their consumption is available via smart meters. Meanwhile, a host of other sources (for instance, decentralised generation, storage and community energy systems) also need to be coordinated. Future business models may depend on the effectiveness of a company's platforms for integrating all the sources in real time, just as Uber, which is essentially a platform, has revolutionised the car hire business[42].

These glimpses from the UK demonstrate that while new technologies such as wind and solar are needed to reduce carbon emissions, they are not the end of the story. Their effect is to change the whole underlying operation and dynamics of the system. The electricity sector is moving from a position where flexible generation responds to uncertain demand, to one where flexible demand is needed to respond to uncertain generation output. This is especially true in areas where local demand flexibility can match local renewable output. Furthermore, we are not speaking about shifting demand from predictable peaks to predictable off-peak periods for an entire system. Rather, we need demand to respond to very uncertain solar and wind output that can be very local (imagine cloud cover reducing solar output at short notice).

There are many proposals being discussed to introduce flexible demand, ranging from different time of use (ToU) tariffs to encourage demand response, to allowing the sale of demand flexibility in energy and ancillary service markets, to more fundamental reforms along the lines of the Keay and Robinson article referred to earlier. These two authors argue that reforms need to reflect the changes underway in the electricity industry that have been driven by two main forces: the increasing penetration of intermittent renewable sources; and developments in information technology, potentially transforming the capacity of electric power companies and consumers to control, monitor and coordinate different sources and activities. Together these developments have fundamentally changed the nature and operations of the sector, turning it 'upside down'. Figure 7 summarises the ways in which the industry of the future is likely to differ from the one we have been familiar with in the past.

[42] See for instance: Strategic partnership with Octopus Energy to transform Origin's retail business», Origin Energy, 1 May 2020. Consulted 14.01.2021.

	2020	Future
Generation cost structure	Mainly marginal	Mainly capital
Generation structure	Mainly centralized	Decentralized
Pricing	Per kWh	?
Planning and operation	Flexible supply to match demand	Flexible demand to match supply
Control and dispatch	From centre	Throughout system (internet)
Role of demand side	Passive	Interactive
Role of grids	Neutral conduit	Smart player

Figure 7. Projected changes to the electricity industry. Source: KEAY, Malcolm & ROBINSON, David, «Glimpses of the future energy system? Demand flexibility and a proposal for a special auction», Oxford Institute for Energy Studies, October 2020, Consulted 10 January 2021.

Oil, gas and coal corporate strategy

The key message from the electricity sector experience and glimpses of its future – that a change in energy sources changes the whole underlying operation and dynamics of the energy system – applies equally to oil, gas and coal companies facing a decarbonised future. The energy transition will require new ways of thinking, and new business models.

It is difficult to imagine a new business model for coal companies unless they are able to develop carbon capture, utilisation and storage (CCUS) technologies that meet increasingly tight carbon emission standards.

In transport and heating, as in electricity, the energy transition will not be simply a matter of replacing fossil sources by renewables; companies will need to consider the dynamics of the new system in prospect and their role in it. Technology change will of course be required as a first step, probably to a mixture of electricity and hydrogen. But either approach leads to a completely new set of system requirements. For instance, EVs would be an active part of the complex new electricity system described above – a main source of short-term storage and flexibility. Government policy and corporate strategy for energy and transport companies will have to change to reflect the nature of the new business. Likewise, if (green or blue) hydrogen[43] is used for residential and industrial heating, this will almost certainly require government policy and corporate strategy that combines electricity with hydrogen gas infrastructure.

The new platforms described above, which may be a key source of competitive advantage, will also help to link transport, heating and electricity sectors. In this new world, companies will need to think about the energy system as a whole, not just about particular sectors like transport or heat.

But, while electrification will be one key vector for decarbonising transport, buildings and some industrial sectors, it will also need to be integrated with a range of non-electric technologies, including decarbonised gases, thermal water storage, wastewater heating and cooling systems and more. Downstream, energy system platforms will assist in the optimization of all energy services, not just electricity.

Upstream, energy system thinking is also important – perhaps particularly for hydrogen, because the economics almost certainly require combining multiple end-product markets for hydrogen in multiple countries, which in turn requires coordination of infrastructures both between and within countries. For instance, in June 2020 Repsol announced a project combining green hydrogen from electrolysis with CO2 to produce lower-emissions transportation fuels[44]. Projects like Repsol's, linking electricity, hydrogen and transport, may be the norm rather than the exception in future; companies will need the skills and expertise to prosper in this complex new world.

Key messages

COVID-19 is offering us some early glimpses of what most longer-term forecasts anticipate for the energy sector. They offer some guidance (what to do and what not to do or avoid) for policy makers and energy companies. Electricity companies have already had ten years to adapt to an industry turned upside down by

43 Green hydrogen is produced via electrolysis using renewable electricity. Blue hydrogen refers to hydrogen produced from fossil fuels, where the carbon emissions are captured and stored.

44 For this fuel to be zero-emissions would require the CO_2 to come from air capture. If the CO_2 came from the combustion of fossil fuels, there would be some CO_2 emitted.

decarbonisation and have had to develop new business models. Very few of them anticipated the enormous scale of the changes and it remains to be seen how many will succeed in the new business environment. Oil and gas companies have not yet had to face the full force of this kind of systemic change; most of them used to argue that they would have time to adapt, using revenues from existing businesses to make the needed adjustments. However, COVID-19 may be a useful wake-up call, not only for the energy sector, but also with respect to the need for advance planning which most western countries failed to do in the public health/scientific sector.

If there is one message for the energy sector it is that the energy business has changed: it is no longer about selling oil, gas, electricity and gradually changing to a lower carbon mix. We are entering into a new paradigm where bottom-up (technology and economics) and top-down (political) pressures are moving in the same direction, towards the need for integrated, fully decarbonised energy systems, where consumer decisions are especially important. Corporate strategy for all energy companies needs to reflect this emerging new paradigm and the possibility that it will arrive faster than expected.

Green recovery and the energy transition

Recovery from COVID-19 is an opportunity to invest in the energy transition. As explained below, many governments have included 'green' recovery measures in their crisis recovery packages – for example grants, public-private investment projects, loans and tax reliefs to support green transport, renewable energy, circular economy, and clean energy research, development and deployment. However, OECD country analysis of green recovery measures indicates that a number of governments have been using the post-COVID pandemic as an excuse to roll back existing environmental regulations and taxes, and increase fossil-fuel intensive infrastructure and electricity[45]. This section examines the economic case for a 'green recovery´ from COVID-19 and illustrates how governments are furthering the energy transition through public funds and new policies.

- First, COVID-19 has caused a serious economic crisis worldwide that governments are trying to manage. Global gross

[45] OECD, «Focus on Green Recovery», 2021. Consulted 23.01.2021.

domestic product (GDP) is projected to fall by more than 5% in 2020 and governments around the world are dedicating enormous resources to support economic activity, alleviate suffering and begin to put people back to work. Government spending on decarbonisation can advance goals in the areas of both economic recovery from the ravages of the pandemic and environmental protection. Government spending will continue, taking advantage of historically low interest rates. But with unemployment, economic hardship and a full economic recovery likely to take years, the challenge is to move beyond short-term spending and to focus on the opportunity to put countries on a more sustainable path.

- Second, if governments are going to meet their decarbonisation commitments, they will have to adopt policies that allocate investment to green energy, related infrastructure and industries that will consume green energy, for instance electric vehicles. One estimate is that with current and planned policies for the global energy sector, investments will be about $95 trillion over the period until 2050, and that an additional $15 trillion will be required fully to decarbonise the energy system. In total, this represents more than 2% of global GDP per year[46]. Most of these funds could come from private investors, but the latter may depend on government funding of pathbreaking projects and the development of related policies to support a coherent long-term strategy for attracting private investment for the transition.
- Third, history suggests that recovery packages can play a role in the energy transition[47], even when decarbonisation was not the primary motivation. In particular, the stimulus measures introduced in 2007-2009 included support for renewables that generated new domestic construction, installation and manufacturing jobs. In the US, loans, grants and tax credits helped to trigger growing investment in solar capacity and solar-related projects. In Europe, stimulus investment in offshore wind and subsidies for wind power helped to make Europe the global leader in wind energy. In Northeast Asia, stimulus spending focused on 'green industrial policy' that helped China, South Korea and Japan to gain international competitiveness in so-

[46] International Renewable Energy Agency, «Global energy transformation: A roadmap to 2050», 2019, p. 11. Consulted 12.01.2021.

[47] JAEGER, Joel, World Resources Institute, «Lessons from the Great Recession for COVID-19 Green Recovery», November 24, 2020. Consulted: 03.01.2021

lar PV and battery technologies; as scale rose and costs fell, these Asian countries exported their products, enabling global penetration of renewable energy and advancing the date when EVs would be cost competitive with conventional vehicles. These investments have not fundamentally altered the trajectory of GHG emissions to date, but they are contributing to the ongoing energy transition and have created competitive advantage for certain nations and companies.

- Fourth, analytical support for green stimulus packages to recover from COVID-19 has come from influential reports prepared by respected thought leaders and institutions[48]. In particular, the Oxford Smith School of Enterprise and the Environment published a report[49] in May that asked whether the recovery from COVID-19 would accelerate or retard progress in fighting climate change. The answer (summarizing the views of hundreds of experts and policy makers) was that some green investments to recover from the pandemic would not only stimulate the economy and create jobs in the short term, but also provide high positive impact on the environment and have a high long-run multiplier effect. In short, the authors argued that it makes no economic sense to invest in carbon-intensive industries and processes because they are not sustainable[50].

For these reasons, most of the major economies have introduced or are planning to introduce some form of green recovery package. Governments in these countries are aware of the need for a long-term strategy to support investment in the energy transition and to create or strengthen the competitive advantage of industries based in the country. The main exceptions are developing countries that do not have the financial strength to pursue a green recovery without external support.

[48] Other influential reports were prepared by the Energy Transitions Commission (ETC) which is Chaired by Lord Adair Turner. See DELASALLE, Faustine & TURNER, Lord Adair. «7 Priorities to help the global economy recover while building a healthier, more resilient, net-zero emissions economy», Oxford Energy Forum Issue 123, Covid-19 and the Energy Transition, July 2020. Consulted 29.12.2020.

[49] HEPBURN, Cameron et al., «Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?», Oxford Smith School of Enterprise and the Environment, Working Paper No. 20-02 ISSN 2732-4214, Oxford Review of Economic Policy 36 (S1), 4 May 2020. Consulted 20.12.2020.

[50] I have co-authored a subsequent report with the authors from the Oxford Smith School and IDMA, «Breve guía para contribuir a la reconstrucción 'verde' tras la crisis de la COVID-19 en España», 24 June 2020. Consulted 09.01.2021.

European Union

The EU has passed legislation that commits over €1.8 trillion to stimulate the economy and to cover its many programmes over the period 2021 to 2027[51]. Of that total, NextGenerationEU (NextGenEU) includes €750 billion that is specifically designed to help recover from COVID-19, while the remaining €1.1 trillion is the EU's seven-year budget (Multiannual Financial Framework, or MFF, for 2021-2027) to stimulate the economy and cover its many other programmes. These sums do not include the substantial investments being made by Member State governments.

NextGenEU and the 2021/2027 budget essentially provide the financial commitment to implement the EU Green Deal[52] that was adopted before COVID-19 and to accelerate digitalisation. At least 30% of this total budget will be dedicated to fighting climate change, and in particular to supporting the energy transition.

Within the Green Deal, the key elements affecting the energy transition fall into four of the eight 'leaves' in Figure 8.

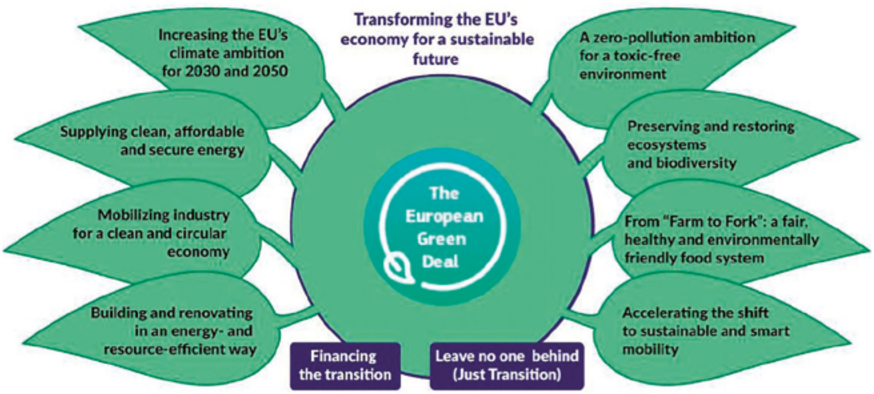

Figure 8. The European Green Deal
Source: «The European Deal Faces Huge Challenges», European Commission.

51 European Commission, «Recovery Plan for Europe» 2020. Consulted 20.12.2020.
52 European Commission, The European Green Deal, COM/2019/640 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588580774040&uri=CELEX:52019DC0640. Consulted 08.04.2021.

More ambitious emission reduction targets for 2030 and 2050

When the Green Deal was approved in December 2019, the EU had committed to achieve a 60% reduction in GHG emissions by 2050 compared to 1990 levels. During the COVID-19 pandemic, the EU adopted a policy of net zero emissions (climate neutrality) by 2050 and a 2030 target to reduce GHG emissions by 55% compared to 1990 levels. To achieve these targets, the EU will use a range of measures that will accelerate the decarbonisation of the energy sector itself and other energy end-use sectors, especially transport and heating. In particular, the EU plans to expand the coverage of the Emission Trading Scheme (ETS) and introduce new environmental fiscal policy to ensure effective carbon pricing throughout the European economy.

The Green Deal is also supposed to protect EU industries from the risk of carbon leakage, i.e. competition from companies in countries that do not face similar carbon taxation or other restrictions on emissions. The Commission has proposed a carbon border adjustment mechanism (CBAM) for selected sectors to reduce the risk of carbon leakage. The aim is to ensure that the price of imports reflects more accurately their carbon content. This proposal is controversial and could raise serious problems for international trade that need to be addressed in its formulation, especially to make it compatible with World Trade Organization rules. However, the environmental objective is valid and the approach is gaining support, notably from the US.

Supplying clean, affordable and secure energy

Energy accounts for 75% of the EU's GHG emissions and so it is not surprising that this is a focus of the European Green Deal. The first priority is to improve energy efficiency. Beyond that, the broad objective is for the power sector to be based largely on renewable sources, complemented by the rapid phasing out of coal and the decarbonisation of gas. The transition to climate neutrality also requires smart infrastructure. The regulatory framework, including the TEN-E Regulation, aims to foster the deployment of innovative technologies and infrastructure, such as smart grids, hydrogen networks, carbon capture, utilisation/storage (CCUS) and other energy storage; and to enable sector integration (for example electricity with green hydrogen). Since the Green Deal was agreed, it is notable that the Commission has indicated its support especially for hydrogen projects involving multiple EU Member States.

Building and renovating in an energy and resource efficient way

Buildings account for about 40% of energy consumed in the EU. The rate of innovation in buildings has been very low and a large share of the European population has economic difficulty heating their homes. To address these challenges, the Green Deal calls for a 'renovation wave' of public and private buildings. This also aims to boost the construction sector and be an opportunity to support SMEs and local jobs.

Accelerating the shift to sustainable and smart mobility

Transport accounts for 25% of the EU's greenhouse gas emissions in the EU, and that percentage is still growing. All modes of transport will be decarbonised, and this will inevitably accelerate the energy transition. On the supply side, the EU plans to ramp-up the production and deployment of sustainable alternative transport fuels. For instance, by 2025, about 1 million public recharging and refuelling stations will be needed for the 13 million zero- and low-emission vehicles expected on European roads. This is a reminder that the European Green Deal is not just about fighting climate change. Transport must also become less polluting (e.g. reduce emissions of NOx and particulates) for reasons of public health, especially in cities. The Commission will propose more stringent pollution standards for internal combustion engine (ICE) vehicles and consider applying the ETS to road transport. It will also take action in relation to other forms of transport.

It is important to stress some important developments of the financial package that was eventually agreed by the EU Member States since they raise the level of climate ambition and offer greater confidence that the ambition can be met. First, the European Commission has for the first time raised money directly to fund credits (not loans) to Member States. Never before has the urgency to act or the political commitment been so great as to justify this. Second, this departure reflects a change in the political balance of power in the EU, away from an alliance of the 'frugal' northern countries (now the Netherlands, Denmark, Sweden and Austria) and towards the others (in particular now France, Germany, Italy and Spain). This shift is significant because Germany did not vote with the frugal countries and because the UK, which would typically vote with the frugal group, was no longer a Member of the EU. The combination of a more powerful European Commission, the departure of the UK and support from Germany enabled the passage of an economic recovery package that was historic in its scale and in its focus on the European Green Deal. Furthermore, COVID-19 and the departure of the UK have strengthened the sense of European unity and the case for using the recovery to enhance the competitive position of European industries in global markets and to play a more ambitious role in global affairs. Of course, there are no guarantees that the EU will deliver on its goals and ambition, but there is greater resolve and confidence than there has been for at least a decade.

China

The 2015 agreement between the US and China to reduce their emissions was the key to obtaining global support for the Paris Climate Agreement. China was keen to present itself as a responsible player on the international climate stage. However, soon after the Paris Agreement was signed, the Chinese economy began to slow, and the government introduced an economic stimulus that had the effect of increasing Chinese coal consumption. The election of President Trump and his support for fossil fuels lessened the international pressure on China to limit emissions, and the subsequent trade war probably lessened the pressure further: However, domestic considerations – in particular security of supply and economic growth – were the main drivers of Chinese energy policy. COVID-19 injected a new element of uncertainty about China's policy on climate change, which might cut both ways. In the words of Sam Geall:

> *On the one hand, it has increased international tensions, which could spur further retrenchment and a focus on energy security, boosting coal-fired power. On the other hand, it [COVID-19] may lead to renewed calls from inside China for a deeper environmental commitment, with Beijing taking the opportunity to lead in the technologies of the future*[53]*.*

The debate over these options in China is taking place in the context of the economic recovery and the preparation of the 14th

[53] GEALL, Sam, «China's climate commitments and energy ambitions beyond COVID-19», Oxford Energy Forum Issue 123, Covid-19 and the Energy Transition, July 2020. Consulted 29.12.2020.

Five Year Plan (FYP). The evidence until recently did not favour decarbonisation[54]. Instead, China has significantly increased its investment and production in heavy industries that rely on coal. In February 2020, the National Energy Administration lowered the risk ratings for coal-power overcapacity in many parts of the country for the third year running, opening the door for more regions to build coal power in 2021–2023[55]. Furthermore, in the preparation of the 14th FYP, there have been proposals for a yet looser cap on coal-fired capacity.

However, this does not mean that China is not investing in the energy transition. There is a lively debate among policy makers between those who favour coal and others who think it is necessary to limit it. Throughout the debate, renewable energy has been growing very rapidly. China has the largest capacities of wind and solar in the world (respectively 240 GW and 230 GW for solar) and capacity is growing steadily. For instance, between January and November 2020, China added 30 GW of wind and 26 GW of solar power in spite of a significant drop in the first three months of the year.

China appears also to have a 'green industrial plan', much as they did in 2007-2009. They have announced ambitious plans for 'new-infrastructure', a term that includes 5G, ultra-high-voltage grid transmission, intercity transportation and rail, electric vehicle charging stations, big data centres, artificial intelligence, and more. This industrial plan is a signal that China is investing in innovation, rather than merely bailing out incumbent industries. China could argue that their infrastructure plan is to electrify the economy, initially using coal, and then to decarbonise the electricity system. They are also driving down the costs of 'green' industries, thereby improving their competitive position in global markets for EVs, batteries and other products aligned with the energy transition.

All of the above was known before President Xi's announcement at the UN General Assembly in September 2020; the unilateral commitment to achieve carbon neutrality by 2060 was a game-changer. It was a surprise to almost everyone and suggests that China may take a greener route than expected. Of course, this did involve some geopolitical gamesmanship with China showing

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54 CHANG, Charles et al., «Economic Research: China's Energy Transition Stalls Post-COVID», 22 September 2020, S&P Global. Consulted 30.12.2020.

55 Ibid.

global leadership while the US was absent. And one could argue that these were empty words since 2060 is a long way away and the other commitment (peaking emissions before 2030) was not very different from what China was already able and committed to doing. However, China has never made a unilateral commitment of this kind and tends to be conservative about its multilateral commitments in the sense that it only commits to what it is confident about being able to deliver.

These commitments are now considered not only as a cornerstone of China's climate-related policy making, but also an encouraging signal to other countries which are committed to combating climate change. Indeed, a number of countries have announced their carbon neutral targets following Xi's announcement, including Japan and Korea. Additional 2030 targets were announced by Xi in the Climate Ambition Summit in December 2020, although they appear to be in line with previous plans. These commitments include the reduction of CO2 emissions per unit of GDP by over 65% from the 2005 level, an increase in the share of non-fossil fuels in primary energy consumption to around 25 percent, and an increase in wind and solar installed capacity above 1,200 GW. The 1,200 GW target would imply an average annual installed new capacity of 70 GW between 2020 and 2030.

We will have to wait at least until we see the 14th FYP for the energy sector to know how China will reflect its international commitments in national energy policy[56]. My sources say that this plan will set the scene for the period to 2035. Furthermore, apparently it is being developed in a way that gives regional governments less influence over the initial drafting, thereby weakening some of the resistance to decarbonisation that is normally associated with provinces that rely on coal and that favour its continued expansion. If this is an accurate report, it suggests that the energy plan will be more ambitious than many expect and send signals for how China plans to decarbonise over the longer period.

United States

The Biden presidential campaign proposed a $2 trillion Green New Deal, setting goals of climate neutrality by 2050, and full decarbonisation of the electricity system by 2035. These goals

[56] There are various plans. The most important, strategic, plan was published in March 2021. The sectoral plans (including for energy) will appear later in the year.

are in line with the targets of the EU and China, although China's is for carbon neutrality by 2060. However, there are serious doubts about the new Administration's ability to pass the sort of energy legislation required to meet those targets. First, the Democrats have a razor thin control over the Senate and the House of Representatives, making it more difficult to pass legislation without bipartisan support. Second, the Administration has already passed a $1.9 trillion American Rescue Plan, which designed to address the immediate dangers of the pandemic and provide direct assistance to those in need; this will probably limit the scale of support for green programmes. Third, the Administration knows it will be challenged in the courts on virtually any measure that does not have bipartisan support[57]. Fourth, the Administration has less than two years before the midterm elections and this places a premium on solving the COVID-19 crisis and quickly putting people back to work. Nevertheless, there is every reason to expect the US Federal Government to do whatever it can to support the energy transition at home and be part of a renewed global partnership to fight climate change, starting with the US re-joining the Paris Climate Agreement.

With respect to a federal green recovery plan[58], it is too early to confirm what the Biden Administration will achieve. However, we now have a clear idea of the objective. At the end of March, Biden presented «The American Jobs Plan»[59], a programme for the reconstruction and modernization of US infrastructure, with investments worth over $2 trillion over an eight-year period. The programme aims to «reimagine and rebuild a new economy», remedying serious deficiencies in the provision of essential services, including bridges, highways, airports and electricity networks, while creating millions of «well paid jobs». However, it is more than that. The overarching political objective is clear: to maintain US supremacy and to out-compete China.

Within that programme, there are many important initiatives to support the energy transition. First, it includes $174 billion to

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[57] BROWER, Derek, Financial Times, «US energy: 'the more ambitious Biden tries to be, the more likely he is to fail'», 21 December 2020. Consulted 28.12.2020.

[58] These measures are separate from using Executive Orders to reverse the previous administration's policies that weakened climate and environmental policies. See «Biden rejoins Paris climate accord, works to overturn Trump's climate policies», Washington Post, January 21, 2021. Consulted 23.01.2021.

[59] https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/

promote the electrification of vehicles, including among other initiatives a national network of 500,000 EV chargers by 2030 and the electrification of at least 20% of the fleet of yellow school buses. Second, the plan includes $100 billion to «re-energize America´s power infrastructure», including building a more resilient electricity grid, which is recognised by both parties as being necessary for improved reliance related to intermittent renewable penetration. Third, the plan proposes a ten-year extension and phase down of an expanded direct-pay investment tax credit and production tax credit for clean energy generation (in particular renewables) and storage. The plan also refers to moving towards 100 percent carbon-pollution free power by 2035. It is too early to know what plan will eventually become law, especially because the intention is to fund the plan through a significant increase in corporate taxation. However, the focus on preparing the US to out-compete China strengthens the prospect that some legislation will be passed that supports the energy transition.

On the international front, the US has re-joined the Paris Agreement and held a Climate Leadership Summit in Washington in late April. They will come to COP26 in Glasgow with a new and presumably ambitious Nationally Determined Commitment (NDC). The administration will use the US International Development Finance Corporation (DFC) to support decarbonisation in selected developing countries, probably in competition with other world powers. It will also use its influence in the World Bank, the IMF, political groupings (like the OECD, G-7 and G-10) and private financial organisations to limit funding to fossil fuels and carbon intensive activities.

For national policy and international negotiations, the credibility of the US federal government ultimately depends on passing legislation that will be difficult for future administrations to eliminate.

The rest of the world

There are many other countries that have announced plans to finance a green recovery. These plans include decarbonisation of energy sources as well as the decarbonisation of industries and the development of industries that will produce goods that consume decarbonised energy (mainly electricity). The UK, most notably, has announced an ambitious ten-point plan that includes financial support for offshore wind, low-carbon hydrogen, new

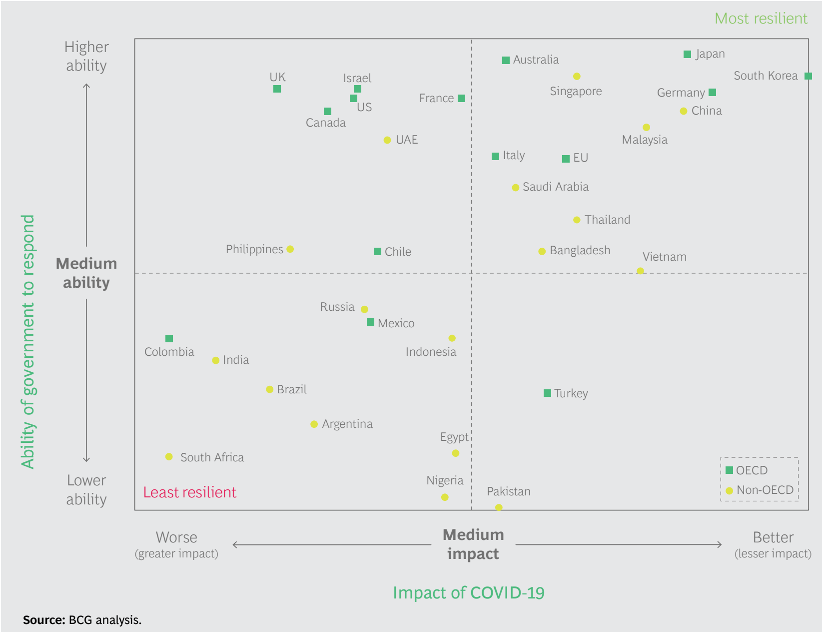

Figure 9. Countries' potential to accelerate energy transition post-COVID-19. Source: BCG analysis.

advanced nuclear, a shift to zero emission vehicles, green public transport, low carbon aviation and maritime transport, greener buildings and carbon capture utilisation/storage (CCUS).

Boston Consulting Group (BCG) has prepared an interesting report on how COVID-19 may affect the energy transition in different countries, based upon the economic impact of the pandemic and the ability of governments to respond[60]. They highlight (Figure 9) in particular the increasing interest and ability of Northeast Asian countries to develop 'green industrial strategies' aimed at supplying global markets for EV's, and to increase generation from renewables.

That framework also highlights the difficulty of delivering a green recovery in the poorest and most populous countries in Latin America, Africa and Asia. Post-COVID-19 stimulus packages that ignore the poorest countries will not only widen global inequality[61], but could also encourage those countries to maintain or

[60] ALKADIRI, Raad et al., «How COVID-19 is changing the pace of energy transitions», BCG, 22 September 2020. Consulted 04.01.2021.

[61] United Nations General Assembly, GA/EF/3531, «Prospects of Quick Global Economic Recovery from COVID-19 Are Unrealistic, Says Nobel Laureate, as Second Committee Begins General Debate», 5 October 2020. Consulted: 04.01.2021.

increase their reliance on fossil fuels, thereby slowing or even reversing the fight against climate change.

Key messages

COVID-19 has provided an opportunity to pursue green policy objectives through the use of fiscal stimulus, taking advantage of very low interest rates. However, government green recovery spending is a small fraction of the investment required to complete a successful energy transition, and its purpose should be to leverage 'green' investment by the private sector. The ambition and the specific investment targets reflect national or regional financial resources and the pursuit of strategic opportunities in specific industries. The EU has been the most ambitious to date, but the US, China and many other countries are committing significant public resources to green energy and 'green industrial strategies'. Indeed, we are witnessing the three great global economic giants taking advantage of the recovery from COVID-19 to prepare themselves to compete in the 21st Century. However, the prospects are poor for a self-financed green recovery in developing countries that were already heavily in debt before the pandemic.

International barriers to a global energy transition

In spite of the many challenges it faces, the global economic system continues to rely on open markets for trade and investment, and more generally international cooperation to address climate change and meet other global challenges, especially the United Nations' 17 Sustainable Development Goals (SDGs)[62]. However, COVID-19 has exacerbated a number of barriers to the global energy transition. One is the retreat from globalisation that was already underway and that was slowing growth of international trade and investment. The other is the deterioration of international cooperation, especially with respect to the poorest developing countries. Conversely, in the fight against climate change, the energy transition could provide the basis for agreements that help to lower both barriers, improving prospects for trade, investment and international cooperation.

[62] «The 17 Goals», United Nations Department of Economic and Social Affairs. Consulted 13.01.2021.

Using the energy transition to enhance global trade and investment

International trade expanded significantly from the early 1990s and had reached almost a quarter of global GDP before the 2008 financial crisis led to a sharp decline[63]. Although trade rebounded briefly, it has not returned to previous growth rates. Part of this may be explained by the economic downturn that shifted the focus to income inequality in the wealthy countries and its causes, including the integration of China's labour force into the global economy. China's trade and investment practices, as well its progress in developing advanced technologies and its importance in global supply chains led eventually to the US-China 'trade war' in 2018, with other major economies also increasingly concerned about globalisation and China. Supply chains were already shortening before COVID-19, with a move away from globalisation and a focus instead on self-reliance.

COVID-19 has reinforced the trend towards self-reliance. It has revealed new risks related to 'just in time' global supply chains for most industries that rely on the timely delivery of intermediary goods. Part of this is related to China, which has become the main source for certain inputs, especially in information and communication technology. But the shift to self-reliance goes beyond China, with the US in particular raising tariffs and imposing trade barriers on many countries (including the UE and Canada with which the US has a history of more open trade), ostensibly to protect domestic industries.

The retreat from globalisation and the rise of protectionism could be much more serious if it slowed global economic recovery following the pandemic. This is quite possible because recovery plans involve investment of public as well as private funds to develop new technologies and businesses that will compete in global markets.

The EU, for instance, is about to invest heavily in green hydrogen, electric vehicles, batteries and other advanced technologies that are consistent with the energy transition and the EU commitment to net zero carbon emissions. The UK, China and many other countries are doing the same thing; seeking to establish a competitive advantage in various industries. Governments and companies in

63 «The post-COVID Economy», Barclays, 14 August 2020. Consulted 13.01.2021.

the EU and other countries have always been concerned about competition from countries with weaker environmental standards. Prior to COVID-19, the EU had already announced its plans to introduce a CBAM to protect its industries against carbon leakage. However, the concern about carbon leakage is significantly greater now as a result of the enormous sums of public finance being invested in new technologies. It would be a political disaster for any government if the investment funded by the taxpayer did not pay off in terms of jobs and international competitive advantage. On the other hand, to protect these investments, the EU or other countries may introduce barriers to investment and trade that raise costs, reduce competition and effectively weaken the incentives to innovate. If the same focus on self-reliance applied in all major countries, this would definitely slow economic growth and weaken the incentives to innovate in favour of a rapid energy transition. To take one example, were it not for the international trading regime that enabled China to export solar panels to the world, the cost of renewables might have remained much higher, and penetration would be far less than has been the case.

What, then, can be done to support freer international trade and investment to support the energy transition, while dealing with the legitimate concerns about carbon leakage, theft of intellectual property and other unfair practices? I think the conditions are now better than they have been for a long time to improve relations among the US, China and the EU, with climate change being one of the few global crises which offers the potential for progress, especially by accelerating the energy transition needed to fight climate change.

- First, each of these political blocs has made or (in the US case) is likely soon to make a commitment to carbon or climate neutrality, in line with an agreed international treaty. This should make it easier than before – although certainly not easy – to reach trade and investment agreements that respect and support the Paris Climate Agreement.
- Second, the recovery from COVID-19 has the potential to stimulate coordinated global economic growth of benefit to all countries. The commercial opportunities from global growth would be severely limited if the major trading blocs introduced further restrictions on trade and investment. Restrictions related to environmental standards should become less necessary as more countries and companies commit to net zero emissions.

- Third, financial regulators and markets around the world clearly favour green investment opportunities and companies that can demonstrate they are not at risk from climate change; few if any corporations can ignore that pressure. Companies that have committed to carbon neutrality are looking for ways to meet their commitments, while investors are looking for ways to use their funds at a time when interest rates are low.
- Fourth, the US and China made headway under President Trump's presidency in addressing some of the most pressing trade and investment concerns, in particular protection of intellectual property in China and reciprocal rights to invest. The EU and China have just recently reached a trade and investment agreement that would appear to deliver similar progress on that front to that enjoyed by the US. According to some sources, the EU-China agreement includes sustainability provisions, including commitments to implement multilateral environmental agreements – notably the Paris Agreement – and to not lower the standards of labour and environmental protection to protect investment[64]. These agreements are certainly not enough to justify confidence, and the EU-China deal may finally not be approved[65], but they are a step in the right direction.
- Finally, COP26 will take place in Glasgow at the end of 2021 and all of the major countries appear ready to make it a successful one. The UK will do everything they possibly can to make that event a success and to highlight Britain's leadership credentials post-Brexit. The EU has demonstrated its intention to continue to lead on global climate change negotiations. China will aim to demonstrate its commitment to carbon neutrality, perhaps by announcing an earlier date for reaching a peak in its carbon emissions. The US will try to regain credibility, ideally supported by new federal legislation, probably with an ambitious NDC and financial support for mitigation and adaptation in the developing world.

With some approximation of these relatively positive conditions in place, in addition to the other pressures discussed earlier in this paper, confidence should be higher than it has been for many

[64] BALIÑO, Sofía, «EU-China Trade Ties in the Spotlight Following News of Investment Pact», IISD, SDG Knowledge Hub, 20 January 2021. Consulted 23.01.2021.

[65] The EU-China agreement requires European Parliamentary approval, which is in doubt following China's decision to retaliate against international (including EU) sanctions for human rights abuses in Xinjiang. https://edition.cnn.com/2021/03/24/economy/china-eu-investment-deal-sanctions-intl-hnk/index.html. Consulted 08.04.2021.

years with respect to improving international cooperation on the energy transition. Yet, there is a need for action to ensure that the opportunity is seized, especially given the global tensions that were heightened over recent years. I would propose three steps to take advantage of these conditions to further the energy transition.

Climate clubs

The first is to build on the Paris Climate Agreement, through joint collaboration agreements, or climate clubs, among the countries best able and willing to lead in the implementation of the agreement, notably the EU, China and the US, but potentially a larger group that have committed to net zero emission targets, including the UK, Japan, South Korea and Canada. The members of the club would jointly make commitments to support innovation, investment and trade that would support realization of the Paris Agreement objectives. They could make other commitments, such as agreeing to link their carbon pricing mechanisms, even if that might only include regional pricing mechanisms in the US. They would agree on a common set of standards related to trade and investment, possibly also guided by principles for a CBAM. We obviously must not underestimate the difficulty of achieving this sort of agreement, particularly since there will be legislation available to protect domestic industries and many companies ready to use it[66]. However, we should certainly make every effort to reach an agreement. The key to the climate club approach is to emphasize the role of benefits as incentives for participation and compliance. In order for the benefits to be effective in inducing participation and compliance, they must be shareable among complying participants and excludable to non-participants and non-complying participants[67]. The greater the economic importance of the club, the greater the incentive to be a member.

Industry-specific agreements

The second, related idea is to establish agreements for trade and investment in specific industries and products, drawing on instruments like a well-designed CBAM that is compatible with

[66] KREIER, Jesse, «Countervailing the EU's Emissions Trading Scheme, Part 2», International Economic Law and Policy Blog, 17 December 2020. Consulted 13.01.2021.
[67] World Bank Group, Climate Strategies, «Carbon Market Clubs and the New Paris Regime», p3, July 2016. Consulted 10.01.2021.

World Trade Organisation (WTO) rules and that has support from members of the agreement. Although the agreement would be industry- or product-specific, it would require government support from all member countries. This measure could be based on the principles used in the Montreal Protocol on substances that deplete the Ozone Layer[68]. That Protocol essentially allows the countries that adopt specified technologies to trade with each other without facing import tariffs from the other members (the carrot), but excludes imports from countries that do not use these technologies (the stick). In the spirit of that Protocol, the wealthy countries would provide assistance to the others. This sort of agreement is suited to specific industries and products and becomes viable only when it attracts enough members to make non-membership very expensive. In the case of the Montreal Protocol, it helped that the population in wealthy countries (especially white-skinned people) were more adversely affected by the hole in the ozone layer than the population in poorer countries. For climate change, the key to mitigating global emissions is in the poorest developing countries, especially in Africa and Asia, where expected emissions growth dwarfs the expected reductions in the global north. The prospect of runaway climate change should provide powerful incentives to direct public and private 'green' investment in the specific sectors to the countries with the greatest potential and lowest cost of emissions mitigations; obviously, it is essential that the investments appear to be profitable and have the necessary guarantees.

Using the energy transition to meet multiple SDGs

Most of Africa, Latin America and some of Asia have been severely affected by COVID-19, leaving them more heavily indebted and with millions more below the extreme poverty line[69] [70]. Unlike the wealthiest countries, they have very limited ability to care for the health of their people and even less to finance an economic recovery, green or otherwise. The experience to date from COVID-19 suggests that they will be the last to receive the most trust-

68 «The Montreal Protocol», United Nations Environmental Programme, UN Environment Portal. Consulted 14.01.2021.

69 CASTANEDA AGUILAR, R. Andrés et al., «Updated estimates of the impact of COVID-19 on global poverty», World Bank Blogs, October 7, 2020. Consulted 23.01.2021.

70 BP Energy Outlook 2020, p29, Consulted 28.12.2020.

worthy vaccines, and will not have sufficient financial resources to stimulate their economies. This can only help to expose and increase the global divide between wealthy and poor nations and to increase the number of people without access to clean energy or health care[71]. In short, there will be a delay in meeting the 17 SDGs (Figure 10).

Figure 10. The 17 Sustainable Development Goals. Source: «The 17 Goals», United Nations, Department of Economic and Social Affairs.

This is not simply a matter of injustice, although it is and will be perceived as such, weakening the willingness of these countries to respond to siren calls for them to slow their economic growth to reduce global emissions. It is also a grave concern because beating the pandemic and defeating climate change are global public goods. Failure to cooperate in addressing these problems on a global basis means that no one anywhere can be truly safe. For a health crisis, the implications are grave, but for climate change they are potentially catastrophic, because these are the countries where energy demand will grow substantially, and where a very large share of incremental carbon emissions will

[71] United Nations General Assembly, GA 12293, «With More Than 1.5 Million Lives Lost to COVID-19, World Leaders in General Assembly Demand Urgent Action to Guarantee Equitable Distribution of Life-Saving Vaccines», 3 December 2020. Consulted 04.01.2021.

occur over the next thirty years if there is no available decarbonized energy alternative. The potential to avoid a climate catastrophe depends on ensuring that economic development in these countries is green and not brown.

The difficulty of global cooperation reflects the familiar problem of the tragedy of the commons. Climate change has always had to deal with the free-rider problem, whereby the national costs for each country to reduce emissions were often greater than the benefits, so the preferred strategy has been, where possible, to let other countries do the heavy lifting. However, today, the economic benefits of a global energy transition, and the costs of inaction, are greater than ever[72].

For many of the same reasons mentioned above, the time is ripe for initiating new international agreements to supplement the Paris Climate Agreement. Furthermore, by supporting an energy transition in these countries, we not only help to reduce the threat of climate change, but also further the realization of other SDG. Here are three proposals.

Donor-recipient or global agreements

The first proposal is for donor countries (together or separately) to adopt measures that will support decarbonisation in the poorest regions in the developing world, especially where emissions are expected to grow quickly[73]. The donor countries would adopt measures such as: debt cancellation, ending public support for fossil fuel projects, scaling up support for green energy and energy access for the poorest, and supporting the bail-out of companies that have stranded fossil fuel assets, conditional on these companies having plans to transition to net zero. As a condition for receiving support, the recipient countries would adopt their own measures, including removing fossil fuel subsidies, incorporating nature-based solutions into their national climate plans under the Paris Agreement, and investing in the restoration of ecosystems. These agreements could include all of the major donors on one side and all the recipients on the other, or involve smaller groups. The donors may be open to col-

[72] World Health Organisation, «COVID-19 intensifies the urgency to expand sustainable energy solutions worldwide», 28 May 2020. Consulted 02.01.2021.

[73] ACT Alliance, «Whose Green Recovery? Why poorer countries must not be left behind by richer countries' recovery plans», 23 October 2020, ReliefWeb. Consulted 12.01.2021.

laboration, for instance with the EU and China working together on specific green investment projects in Africa. On other hand, competition to invest in green investment projects should be welcome, and public funding should aim to leverage private investment.

Not all of the agreements need come with conditionality. For instance, the COVAX Facility involves governments and companies from higher income countries. Its aim is to ensure that COVID-19 vaccines and drugs reach those in need, whoever they are and wherever they live. One of President Biden's first decisions was for the US to join this global effort, which has struggled to achieve its mission[74]. Similar agreements could provide the basis for assistance to the most needy countries in the interest of promoting the energy transition.

Clearly, none of this will be easy. For example, debt cancellation is extremely complicated and will depend on the country and the type of investor. Furthermore, COVAX could fail due to vaccine nationalism. Nevertheless, it is critical to take advantage of the improved conditions for international collaboration, resulting in part from the election of President Biden, to promote the initiatives that can accelerate the energy transition in the world's poorest countries.

Offset markets

Second, private and public financial institutions should consider the potential to develop new offset markets. Mark Carney recently made the case for creating new capital markets to support green investments in developing countries, in particular through offsets[75]. He pointed to the enormous demand ($100 trillion) for sustainable investments and the capital that companies were ready to commit to invest in order to reach carbon neutrality. Since much of the world's incremental energy-related investment will happen in the emerging and developing countries, this is where a significant share of the offsets should take place. But for that to happen, Carney argues, some public funding for projects will be required to attract the enormous resources available from the private sector. There are serious concerns about offset mar-

[74] MANCINI, Donato P., «US joins global vaccine efforts on Biden's first day», Financial Times, 21 January 2021. Consulted 24.01.2021.
[75] KIRKA, Danica, «UN envoy lays out strategy for financing climate battle», AP News, 9 November 2020. Consulted 20.12.2020.

kets, not least the incentive to weaken decarbonisation in wealthy countries, and the difficulty of ensuring that the offsets actually deliver real emission reductions and are not simply green washing[76]. Nevertheless, I consider this to be an initiative that has the potential to attract significant incremental financial resources for decarbonisation in developing countries and requires policy and financial market support as well as clear rules to avoid green washing.

Support to the losers

Finally, the energy transition will inevitably involve winners and losers, among countries and within them. Domestically, many wealthy countries are adopting 'fair transition' strategies. Internationally, either individually or as part of a regional group (EU), or a multilateral agreement, the 'winners' should consider strategies that will assist the losers to make the transition.

Key messages

A successful global energy transition will require international agreements to support green innovation, trade and investment, and to support the energy transition in the poorest developing countries. It will also require mechanisms to compensate the losers. It is very easy to argue that these proposals are virtually impossible to achieve, especially now because of the growing tension between China and the two other global economic powers, the US and the EU. I do not accept that conclusion for four reasons. First, each of these great powers is accelerating the energy transition for domestic reasons: eventually to reduce costs and immediately to improve the health and quality of life of its citizens. Second, there is now a competitive race among them to achieve carbon neutrality and to export their green technologies and products; some people compare this with the «space

[76] Indeed, Carney himself has been accused by some green finance experts of greenwashing, by claiming that Brookfield, a company of which he is Vice Chair, had «net zero» emissions across its portfolio because the «avoided» emissions from its renewable business compensated for the positive emissions from other businesses, including coal. https://financialpost.com/financial-times/mark-carneys-big-stumble-at-brookfield-intensifies-focus-on-net-zero-emissions-claims. For more on what constitute credible carbon offsets, see the Oxford Offsetting Principles, https://www.ox.ac.uk/news/2020-09-29-oxford-launches-new-principles-credible-carbon-offsetting.

race» of the past[77]. Third, for the many reasons explained in this chapter, a growing number of the world's major private and public financial institutions and corporations have made commitments to carbon neutrality; their markets are global, and their futures depend on the credibility of their commitments. Finally, COVID-19 has created unique set of political and economic conditions that justify public investment that would have been impossible previously. The urgency to make every effort could not be greater.

Summary conclusions

1. The energy transition underway does not guarantee that the world will meet the Paris Climate Agreement target. There is no compelling reason to be optimistic about that. Nevertheless, the faster and more effective the attempt is, the better the prospects of limiting climate change.
2. The pandemic is a cautionary tale that should remind us of the importance of respecting nature's limits, thinking long-term, taking early action and adopting the precautionary principle. In terms of making the energy transition effective, we should be more aware now of the importance of global cooperation, science and innovation and the critical role of competent governments, especially in addressing social concerns and in working with civil society and private investors.
3. The energy transition changes everything. It is not just about replacing fossil fuels with renewables. It is about changing the entire energy system, which will become increasingly electric. It is about improving efficiency and developing the industries and products that will consume electricity or other renewable energies. It is about decentralisation of decision-making, as consumers become more active participants in the energy system. Just as oil created path dependence that drove global innovation, economic and political development for more than a century, so will the energy transition create a new path.
4. The COVID-19 pandemic is a pivotal moment in the energy transition. In some ways, it reinforces the pressures favouring the transition and offers guidance on what needs to

[77] Stephanie Butcher, «Europe's chance to lead the Green technology race» *Financial Times*, 1 April 2021. https://www.ft.com/content/195bb547-8b01-4c99-a789-f77e8b779620

change. The need to recover from the pandemic also provides a justification and an opportunity to dedicate significant public and private resources to the energy transition. The recovery is an opportunity for companies and countries to create competitive advantage and to set the standards for the new path.

5. Energy corporations have some new information that should lead them to reflect on their strategies. COVID-19 may have offered glimpses of the future and suggests that we are moving towards integrated, fully decarbonised energy systems, where consumer decisions are increasingly important. The power sector has already had many years to begin to adapt to that reality. Oil, gas and coal companies can learn from that experience and should be planning for an earlier peak to global demand than they had anticipated before the pandemic.
6. The energy transition creates opportunities and threats for industries. Global markets will certainly grow for electric vehicles, batteries, heat pumps and other electrical devices and green technologies, as well as for services to support electrification and consumer participation. Likewise, markets will increasingly support companies in process industries like steel and cement that rely on decarbonised energy sources and other inputs, and penalize those that do not. Obviously, corporate strategy should reflect the changing global market preferences for green products.
7. COVID-19 has increased the public recognition of the importance of government policy and competence. Governments have a particularly critical role in dealing with social challenges during the energy transition and in providing support for the science and innovation that is required for that transition. They are also critical to an economic recovery that provides short-term stimulus and supports the development of sustainable economic activities. However, while most of the investment funds could come from private investors, private investment may depend importantly on government funding of pathbreaking projects and the development of policies that encourage private investment in support of the transition.
8. COVID-19 has exposed and in some respects exacerbated other serious global challenges, including rising protectionism on a global basis, and increasing debt and poverty in developing and emerging countries. These could well slow the

energy transition, especially in the countries where it is most needed to avoid a major increase in global GHG, and where the transition could actually help to advance other SDGs, such as the end to poverty. To meet these challenges, this chapter has made the case for greater cooperation among nations as well as the development of efficient financial markets to allocate capital in ways that reflect climate-related financial risk.

9. Finally, although there are powerful reasons to doubt the willingness of the world's great economic powers to collaborate, this chapter argues that each of them has national motives to accelerate the energy transition and to attempt to win the global race towards carbon neutrality.

End comment

I would like to end by highlighting some recent news that underlines the enormous challenge we face and provides reasons for being somewhat more positive concerning the potential to fight climate change and to accelerate the energy transition globally.

The first news item comes from the International Energy Agency, which has warned of the recent increase in carbon emissions associated especially with coal-based generation in the emerging nations, in particular China. After a reduction of 5.8% in 2020 due to the pandemic and measures to control it, the Agency expects carbon emissions to rise by 4.8% in 2021. This is not a surprise, but it does confirm the necessity to accelerate the energy transition, especially in the power sectors of the emerging and developing countries of Asia, Africa and Latin America.

The more positive news relates to the improved prospects for international collaboration in the fight against climate change. First, in spite of the tension between the US and China on many fronts, the two countries have now committed to collaborate with other countries to address the climate crisis. Second, in the Climate Leadership Summit (on International Earth Day), President Biden announced a new US objective to reduce greenhouse gases by 50-52% in 2030, compared to 2005 levels, doubling the previous US commitments. He also presented an «International Climate Finance Plan» that is dedicated to mobilizing resources to assist developing countries in reducing or avoiding GHG emissions and in building resilience against climate change. Other countries also made more ambitious commitments, including Brazil and Canada, while the EU emphasized its commitment to climate neutrality, its green recovery plan and its contribution to global green finance. However, the importance of the Summit was the attempt by Biden to convert the US into a global leader on climate change. As explained in this chapter, the US will have to pass federal climate legislation before it can be a credible leader. Nevertheless, the agreement between China and the US and the more ambitious commitments from the US and other countries are very welcome news.

This most recent international political news adds to the momentum for an accelerated global energy transition that has been building due to financial, corporate and social pressure for decarbonization, the adoption of green recovery plans, and in particular the technology innovation that is making the transition more affordable. COVID-19 is certainly not the main reason for the acceleration and some will say it played little or no part. Nevertheless, I hope at least to have demonstrated that the transition has not stopped during the pandemic and that COVID-19 has improved the prospects for the energy transition and facilitated a better understanding of how to realize it.

Chapter two

Geopolitics under the green deal: a challenge for the EU

Miguel Ángel Lasheras Merino

Abstract

At the same time that the EU Commission announced in December 2020 the Green Deal (GD) aimed at transforming Europe into an emission-free society by 2050, the COVID-19 virus began to settle in the world. The Green Deal defines a set of objectives and tools whose scope and use, as initially formulated and developed throughout 2021, place the EU before the greatest challenge assumed since its foundation. This article describes this set, and locates them in an energy and environmental policy that has become the backbone of the unity and cooperation of Europeans and the core of the leadership sought in the foreign action of the Union. The appearance of the pandemic, far from altering the formulation of the GD, has reinforced its relevance as a substantial part of the recovery process initiated by community institutions. Supporting investments in new technologies (such as electrification, renewables, hydrogen and smart grids) and funds aimed at a Just Transition, that offset the costs caused by this transformation process, will require a mobilization of public and private resources greater than that of any other process initiated from the Union. And the Union appears ready to meet this challenge along with its costs. The ecological transition in the midst of a crisis of the international order forced mainly by the new weight of China in the world will force to seek new cooperation frameworks and operate in fields of competence unknown until now. The very existence of the EU seems to be linked to the success of this process.

Keywords

European Union, Green Deal, Just Transition, decarbonization, international order, cooperation, circular economy.

GEOPOLITICS OF THE EUROPEAN GREEN DEAL

CRISIS OF THE INTERNATIONAL ORDER BASED UPON NATIONAL SOVEREIGNTY

CLIMATE CHANGE AS A TRANSNATIONAL PHENOMENON

MOBILISING RESEARCH AND FOSTERING INNOVATION

TRANSFORMING THE EU's ECONOMY FOR A SUSTAINABLE FUTURE

THE EUROPEAN GREEN DEAL

- INCREASING THE EU'S CLIMATE AMBITION FOR 2030 AND 2050
- A ZERO POLLUTION AMBITION FOR A TOXIC-FREE ENVIRONMENT
- SUPPLYING CLEAN, AFFORDABLE AND SECURE ENERGY
- PRESERVING AND RESTORING ECOSYSTEMS AND BIODIVERSITY
- MOBILISING INDUSTRY FOR A CLEAN AND CIRCULAR ECONOMY
- FROM "FARM TO FORK": A FAIR, HEALTHY AND ENVIRONMENTALLY FRIENDLY FOOD SYSTEM
- BUILDING AND RENOVATING IN AN ENERGY AND RESOURCE EFFICIENT WAY
- ACCELERATING THE SHIFT TO SUSTAINABLE AND SMART MOBILITY

FINANCING THE TRANSITION

LEAVE NO ONE BEHIND (JUST TRANSITION)

THE EU AS A GLOBAL LEADER

A EUROPEAN CLIMATE PACT

GEOPOLITICAL CONSEQUENCES OF THE EUROPEAN GREEN DEAL

Introduction

In 1916, and despite growing economic inequality, populist nationalisms, political violence and terrorism, the European Union's (EU) strategy in foreign action and security considered that: «these are also times of extraordinary opportunity. Global growth, mobility and technological progress – alongside our deepening partnerships – enable us to thrive, and allow ever more people to escape poverty and live longer and freer lives» [1].

In recent years, climate change[2] together with the huge increase in human migratory movements, the new technological revolution, and since March 2020, COVID-19, have made Europe face an unprecedented challenge. Since the beginning of the 21st Century the world has become more complicated, and instead of moving towards closer international cooperation, uncertainty and rivalry seem to be pushing the planet in the opposite direction.

In December 2019, the EU Commission formulated the European Green Deal (EGD), which in its final paragraph states the following: «The European Green Deal launches a new growth strategy for the EU. It supports transition of the EU to a fair and prosperous society that responds to the challenges posed by climate change and the environmental degradation, improving the quality of life of current and future generations». Growth and progress, the fight against poverty, increasing life expectancy and even consolidating liberties, now have a common goal in the EU: obtaining a sustainable and clean development. Yet, to achieve such a world, will compete with other futures that are not so promising[3].

As we enter the third decade of the 21st Century, climate change is causing risks that constitute a global and collective problem that calls for international cooperation. It also requires strong and sufficient individual support, firstly because this is undeniably

[1] European Union Global Strategy: «Shared Vision, Common Action: A Stronger Europe» June 2016. https://eeas.europa.eu/sites/eeas/files/eugs_review_web_0_0.pdf (Consultation Date January 2021).

[2] Climate change means the global variations affecting the Earth's climate. These variations are due to natural causes and to human activity and affect all climate parameters: temperature, precipitations, cloudiness, etc, at very different time scales. https://www.miteco.gob.es/es/cambio-climatico/temas/cumbre-cambio-climatico-cop21/el-cambio-climatico/ (Consultation Date January 2021).

[3] For example, NYE, Joseph: «Los futuros posibles tras la pandemia». In El País on 11 October 2020, he describes several potential scenarios for 2030 and only one of them is consistent with the consolidation of an international green agenda.

the basis for giving legitimacy to political decisions in democratic societies and, secondly, because the responses to climate change make it essential for us not only to find new ways of consuming and producing, but also to change our work habits and the ways in which we relate to each other. Shortly, this means modifying our current lifestyles.

The economic doctrine considers environmental protection to be a public good because of its non-exclusive and non-individualizable consumption[4],and climate change induced by human behaviour to be an externality or cost that is not borne by those who cause it but by everybody in general[5]. Mitigating climate change requires collective actions that must involve all countries and nations as a whole,[6] whether they are developed or developing countries, whether they are from the North or the South and however democratic they may or may not be. An international response is needed «based on a shared understanding of the long-term objectives and an agreement on the institutional frameworks for action»[7]. Yet just like any other global collective action, acting against climate change also brings about incentives to act as opportunists or free riders, i.e., obtaining the benefits of the actions taken by others, without bearing their cost.

Collective action in defence of the environment is also jeopardised if it cannot find sufficient social support for the political decisions it implies and fails to encourage changes in the individual behaviour. Paradoxically, these support and modifications of individual habits rather than due to their real impacts on the climate, are usually adopted according to how each person values the esteem that her actions induce in the closest social environment. The actual effect on global warming or on the CO2 emissions of a

[4] These are the basic features of a public asset according to SAMUELSON, PAUL: «The Pure Theory of Public Expenditure», Review of Economics and Statistics 36 (4), Pages 387-89. (1954)

[5] Although the source of externalities as an economic concept is attributed to PIGOU, A.C.: «Wealth and Welfare» (1912), a specific application of this term to climate change appears in the STERN N. Report, Review on the Economics of Climate Change. 2006. Available at www.sternreview.org.uk. (Consultation Date January 2021)

[6] These collective actions can also be regarded as included in the «Prisoner's Dilemma» model, where the optimum strategies of each individual or country lead to socially suboptimal equilibrium. CONTHE, MANUEL: «Geopolítica de la Energía y Teoría de Juegos». In Energía Geoestrategia 2019. Instituto Español de Estudios Estratégicos. *Comité Español del Consejo de la Energía. Club Español de la Energía. Ministerio de Defensa*. 2019.

[7] STERN, N. *Ibid* (2006)

particular attitude or a specific individual action, is very marginal and hardly appreciable. That is why obtaining sufficient social support to combat the anthropogenic effects on the climate, is regarded as one of those problems of the kind that is described in economics as «tragedy of the commons»[8]. The «tragedy» consists that if individuals rationally make their decisions (they decide in favour of what is most beneficial to them), they cause a collective result that is self-destructive. They are decisions that are taken not because of the state of the world, but because of what we are like or what we want to be like.

If the actions to combat climate change are to be successful in the next few decades, inducement to behave as opportunists or free riders must be discouraged, and the same applies to any opposing decisions and attitudes adopted by individuals who, for a variety of reasons, question the feasibility of such actions and their implementation speed, or those who even question the very existence of climate change. For this purpose, it is essential to mitigate the asymmetries that, in terms of geo-political power and social welfare, this transition will cause. If combating climate change is to make headway, international cooperation and social support have to overcome the interests, asymmetries and inequalities that induce negative and uncooperative behaviours.

Although the European Union strategy and its foreign policy have not been particularly influential over the last three decades, it seems to be awakening since the approval of the European Green Deal and the political reaction to COVID-19[9]. After the EGD was formulated in December 2019 and the Reconversion Plan to refloat the Union's economy was drawn up in April 2020

[8] This is what Steven Pinker in «Enlightenment Now: The Case for Reason, Humanism and Progress». Viking, New York, 2018, states to remind us that it is a behavioural model that generates negative externalities and that this model is referred to as «tragedy of the commons», originally described by Hardin in 1968 in the journal Science. Pinker, following in the wake of Kahan et al. identifies the beliefs surrounding the effects of climate change as a problem that is in keeping with this collective action model. KAHAN, DAN M. WITTLING; MAGGIE et al, in *The Tragedy of the Risk-Perception Commons: Culture Conflict, Rationality Conflict, and Climate Change*. Temple University Legal Studies Research Paper No. 2011-26, Cultural Cognition Project Working Paper No. 89, Yale Law & Economics Research Paper No. 435, Yale Law School, Public Law Working Paper No. 230, Available at SSRN: https://ssrn.com/abstract=1871503 or http://dx.doi.org/10.2139/ssrn.

[9] BERGMANN, Max: «Europe's Geopolitical Awakening. The pandemic rouses a sleeping giant.» Foreign Affairs, 20 August 2020.

and finally accepted in December, the EU has made an attempt to take over world leadership in the process of transition towards a decarbonised world. If it is to achieve this leadership, the EU has to be prepared to take on the risks involved and to face up to the internal and external tensions that it could entail, including those that internally affect its own political project, such as, for example, that the transition is unsuccessful and gets diluted in the geopolitical tensions of a fragmented world[10].

This article is structured as follows: after this introduction, there is a section devoted to explaining, as international precedents to the EGD, the crisis situation of the international order at the beginning of the 21st Century and the origins of a new supranational framework of action in support of the fight against climate change. The third section traces and describes the path taken by EU energy policy until the EGD became the core strategy of the Union's domestic and foreign policies at the end of 2019. The fourth section concerns the EGD, its objectives, its policies and the requirements that have defined it throughout 2020. The fifth section gives an account of the main geopolitical consequences that the EGD may bring about and, by way of conclusion, the sixth section consists of a general reflection on the repercussions of the EGD defined by the EU, as it is implemented.

Climate change and green transition in an international order in crisis

The international order crisis

After the Second World War, the international order led by the United States of America (US) was based upon the doctrine of containment through deterrence. It was able to contain the danger of uncontrolled nuclear expansion; turned Germany into a democracy; provided financial support to the reconstruction of Europe through the Marshall Plan; forged new alliances in Asia and Europe; established and consolidated several multilateral institutions, such as the United Nations, the International Monetary Fund, the World Bank and the World Trade Organi-

[10] At the moment the EGD was defined, in December 2019, Giuseppe Conte, then Prime Minister of Italy, warned his European counterparts that Europe was facing «an appointment with History» that ran the risk of «ending up in failure». Quoted in COLOMINA, CARME. «Una Union Europea en Transición». CIDOB. Barcelona Centre for International Affairs. anuariocidob.org. July 2020.

zation, amongst others. All these advances would have been described as pure utopia right at the end of the Second World War[11].

After the fall of Communism in the Soviet Union and once the Cold War ended, the US acquired a largely unexpected economic and military superiority and could have led a new phase of international cooperation. Yet the Governments in the 1990s, both Bush Senior's and Clinton's, proved unable to work out a strategy that would have taken US foreign policy beyond the defence of its own immediate interests and the simplest values of capitalism. It was thought that: «No two countries that both have a McDonald´s have ever fought a war against each other»[12]*.* After all, the use of force, i.e. the military power, was always an option, should the expansion via McDonald´s not be sufficient[13].

Once the 1990s had passed, the US and the Western World found themselves up against two unexpected phenomena: the boom in Moslem terrorism and China's spectacular economic growth. The terrorist attacks on 11 September 2001 finally closed that window of opportunity and drove the US to a foreign policy that, in an attempt to prevent further terrorist actions, led to the unilateral waging of wars, such as the ones in Afghanistan, Iran and Iraq. Even with the benefit of hindsight, these wars were difficult to explain, and after having cost the lives of thousands of US soldiers and hundreds of thousands of civilians, they gave rise to a geopolitical notion that did not consider the main problems to be transnational and thus failed to realise that the solutions also needed to be transnational, «… diplomatic, multilateral and inherent to a foreign policy that would enable other countries to manage their domestic problems instead of expanding them beyond their frontiers»[14]*.*

Once Trump came into Office in 2017, US military and economic supremacy went into crisis and was questioned owing to China's rise as an economic force. In these recent years, the USA has given up the multilateralism of previous periods (its new target

[11] HAASS, Richard: «Present at the Disruption: How Trump Unmade U.S. Foreign Policy» Foreign Affairs. October 2020.

[12] FRIEDMAN, Thomas: «Foreign Affairs Big Mac». New York Times 8 December 1996.

[13] ZARIFIAN, Julien: «U.S. foreign policy in the 1990s and 2000s, and the case of South Caucasus (Armenia, Azerbaijan and Georgia*)».* European Association for American Studies. European Journal of American Studies. Summer 2015.

[14] FUCHS, Michael F.: A Foreign Policy for the Post-Pandemic World: How to prepare for the next *crisis*. Foreign Affairs. 23 July 2020.

becoming «America First»[15]) distancing itself from the Joint Comprehensive Plan of Action (JCPOA) for controlling Iran's nuclear expansion, from the Paris Agreement and the World Health Organisation, and plunging the World Trade Organisation (WTO) into crisis. The 2020 Elections paved the way for a new Administration under the Presidency of Joe Biden from whom it is hoped that there will be a change in direction that will enable the USA to reappear as the «hegemonic and benevolent stakeholder» it was in earlier times. The return to the Paris Agreement and the announcement that a New Green Deal will be considered in the US will set a new balance in the world's environmental policies, although nothing will be quite the same again.

Shortly before Trump took over the presidency, Martin Wolf stated in the Financial Times that the moment the world was going through could be regarded as «*...*the end not only of an economic period – globalisation led by the West – but also the end of a geopolitical era, the unipolar moment after the Cold War, that of a global order led by the US»*.* This period has come to an end and we are at the outset of a new era with new objectives, new methods and new institutions.

Dani Rodrick's trilemma,[16] is well known. It is used to argue that hyper globalisation is incompatible with liberal democracy and with maintaining Nation-States as the basic and sovereign unit for political decision[17]. The principles of the international order that have prevailed in previous decades and that we can identify with those of an «international liberal order» – difficult to define with precision but abundantly quoted – have been in crisis for several years and have been questioned from the East and from the West[18].

[15] «America First» is not an empty slogan devoid of content, but a philosophy that is fairly consistent with a long tradition and has many followers in the US academic world. See KAGAN, ROBERT: «The twilight of the liberal world order». Brookings Big Ideas for America. Policy Brief. 24 January 2017.

[16] «Rodrick's trilemma» indicates that it is impossible to achieve economic globalisation, political democracy and national sovereignty, all at the same time. The three options at the same time, are incompatible, because once two of them hold; this prevents the third from occurring, so we will be forced to choose only two at the same time.

[17] RODRICK, Dani (2011), «The Globalization Paradox: Democracy and the Future of the World Economy»Norton, New York.

[18] As is accepted by RABINOVICH, MARYNA and ZUZANA REPTOVA: «The future of values in the EU global strategy 2020» Strategic and international studies. Real Instituto Elcano. 19 November 2019: for the US and the EU, there is no doubt that the annexation of Crimea (2014) and the actions taken by Peking regarding its claims based on

China and Russia, countries that can hardly be said to epitomise the definition of liberal democracies, happen to be the main challenges to the international order in recent years, owing to their relatively great economic, military and political power and their clear readiness to use it. China's positioning with regard to international trade is not only a positioning in defence of its own economic interests. The country also seeks to occupy an ideological role in the world that currently appears to be vacant. [19] The «international order» of recent decades has seen progress in human rights, democracy and the autonomy of the individual, but on the other hand, from a political and economic perspective, it has sought to expand through colonial violence and by subordinating the material and personal resources of the peripheral countries to the «mothercountry»[20]. Critics of this order with regard to China have in their favour the fact that in the past 40 years, China has managed to lift 800 million people out of poverty. Whereas at the beginning of the 1990s, the Soviet Regime collapsed in Russia and Eastern Europe, the peculiar Chinese Regime has managed to take the country into second place in the world rankings in terms of nominal GDP. China has sacrificed domestic democracy in an effort to consolidate itself as the world's top exporting nation.

All in all, according to Charles Powell, Director of the *Real Instituto Elcano*, although the declining international liberal order, which was the driving force behind globalisation and multilateralism, is fraught with uncertainties and concerns, it is looked upon in some parts of the world «…even with hope, because it could pave the way for a new multipolar order that is more egalitarian, inclusive and stable than the current order.»[21] This ought to be

the «Nine-Dash Line» in the South China Sea amount to a threat to international order that claims to be based on shared rules (yet it is paradoxical that Washington accuses Peking of violating the United Nations Convention on the Laws of the Sea, when the US Congress has refused to ratify this Convention because it considers it to be incompatible with the free exercising of its sovereignty).

[19] We must not forget that, for example, Chinese behaviour has been paradigmatic in the same heart of the EU. When no other European country responded to the Italian Government's urgent call for medical equipment and personal protective equipment, China reacted by sending 1,000 items of ventilation equipment, 2 million masks, 100,000 respirators, 20,000 protective suits and test kits, as is pointed out by CASTIÑEIRA, Angel: «COVID-19 and geopolitics: first impacts» Global Agenda. ESADE 29 May 2020.

[20] NOONAN, Jeff. «Trump and the Liberal International Order», International Critical Thought, 10:2, 182-199, DOI: 10.1080/21598282.2020.1779601. June 2020.

[21] POWELL, Charles: «Tiene futuro el orden liberal internacional?» Estudios Internacionales. Real Instituto Elcano. 29th June 2017.

an order that is able to take on the international fight against climate change and provide cover for the cooperation required to progress towards a decarbonised world that is environmentally sustainable.

Climate Change

When the EU talks about Climate Change it is referring to the fact that *the atmosphere is warming and the climate is changing from one year to the next. One million out of the eight million species on the planet are in danger of extinction. We are polluting and destroying the forests and oceans*[22]. The Intergovernmental Panel on Climate Change, an organisation belonging to the United Nations and that periodically issues scientific, technical and soci-oeconomic reports for the UN Framework Convention on Climate Change[23] , considers that *the scientific evidence of the warming of the climate system is unequivocal*[24]. The Fifth Report from the Intergovernmental Panel was vital for ensuring that the Climate Conference held in Paris in December 2015 put the Convention Parties to one accord in signing a commitment to act jointly, trying to prevent this global warming. The Paris Agreement *is based on the Convention and, for the first time, it has given the countries a common cause to undertake ambitious efforts to combat climate change and to adapt to its effects, with increased to help developing countries to do likewise*[25]. The main aim included in the Agreement is to limit the temperature increase to 2ºC, when compared to preindustrial levels and, if possible, to limit this increase to 1.5ºC. It is the first time that within the national order, still based above all on respect to national sovereignty, it has been possible to obtain a world agreement with quantified targets taken on by the Parties with regard to adopting policies that affect the exercising of their sovereign rights. Although the Agreement was not signed by all the Parties to the Convention

[22] COM (2019) 640 final.

[23] The Convention is an international treaty signed in New York on 9 May 1992 that seeks to increase public awareness all over the world regarding climate change problems. In 1997, the legally binding Kyoto Protocol was added to it. This Protocol was only binding to the developed nations and established new practical measures (such as the three flexibility mechanisms that it defined: Emissions Trading, the Clean Development Mechanism and the Joint Implementation Mechanism).

[24] https://climate.nasa.gov/evidence/

[25] https://unfccc.int/es/process-and-meetings/the-paris-agreement/que-es-el-acuerdo-de-paris

(by the end of 2020, 187 out of the 197 Parties had ratified it), it managed to achieve an unprecedented mobilisation in favour of policies to combat climate change[26].

Not long before the Paris Conference, in September 2015, the United Nations Assembly approved Agenda 2030 concerning Sustainable Development that sets 17 targets to be reached that range from poverty eradication to combating climate change, education, equality of women, defence of the environment or the design of our cities[27]. In the Report submitted to the Assembly shortly before approval of the Agenda, the UN Secretary General made reference to the 17 goals and 169 associated targets, stating in the final paragraph: «The threats to international peace and security are becoming increasingly complex and interconnected, which is why we are required to examine and update our approach to conflict prevention, keeping peace and consolidating peace. These are just some of the challenges that must be overcome, and that require an unprecedented spirit of cooperation between the Member States. Let us all work together to achieve these common goals.»[28] These targets are enumerated in the Agenda, but there is no legal requirement to comply with them, and neither are there any common methods defined for quantifying them[29].

In a world whose international order is based on respect for the sovereignty of every Nation-State, the Paris Agreement constitutes a break away from this base and provides an experience on which to build a series of new rules of the game. The requirement to act, taken on by the signatory States, does respect the autonomy of each Party or State to define which tools to use, but it imposes clear obligations on them regardless of the tools they use[30].

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[26] Even a company that is as fully oil oriented as British Petroleum admitted in its Energy Outlook for 2020: *Delaying these policies measures and societal shifts may lead to significant economic costs and disruption*.

[27] https://www.un.org/sustainabledevelopment/es/

[28] «The Secretary General's Report on the Organisation's activities». General Assembly. Official Documents. Seventieth period of sessions. The United Nations. New York, 2015.

[29] LORENZO, Claudia: «Medición de los Objetivos de Desarrollo Sostenible en la Unión Europea a través de indicadores compuestos». Work Document. Special Issue. Fundación Carolina, April 2020, an attempt is made to use this quantification for the UE Member States in 2016 and 2017 utilising synthetic indicators.

[30] This is the principle of «sovereign obligation» which Haass defines as an alternative to national sovereignty and which should lead to a new world order 2.0. See HAASS, RICHARD, *Ibid.*

The US, which ratified the Paris Agreement in September 2019, formally informed in November that it was withdrawing from the Agreement as from November 2020. President Trump had already formally announced this withdrawal in July 2017, seven months after taking possession. The USA thus became the first major world power to withdraw from an Agreement in which the rest of the major powers remained, including India, China, Russia, the European Union, Japan and Brazil[31].

The EU, which is energy dependent and until relatively recently (until the beginning of the Millennium) did not have an energy policy as such, i.e., one of its own and different from that which was implemented by each Member-State, approached the green transition after the Paris Agreements, from a position of great institutional weakness (Brexit, slow decision-making processes that require unanimity for key matters such as taxation and budgets, poorly-managed increase to 27 members, crisis affecting migration policies, etc.) that, together with taking into account the effects of COVID-19, put it in a relatively marginal position in the current world concert of nations. However, since the spring 2020, the Union seems to have been overcoming this situation and finding a new way to tackle its current challenges: with new decision-making formulas, new tools and a new sense of unity. In his 2017 speech on the State of the Union, President Juncker made a clear reference to the fact that important decisions for market unity, the Council's decisions and those involving the European Parliament, should be taken by qualified majority. In the words of the Commission: *there comes a moment when the unanimity rule slows down progress and in some cases prevents the EU from adjusting to changing realities and offering Europeans the best means for defending their interests*[32]. The qualified majorities rule is now applied to protect the environment & consumers, employment & social standards, data protection and free & fair trade. Let us hope it will soon be applied to the rest of the important EU´s decisions.

[31] In a year, 2020, when forest fires and hurricanes in the Gulf of Mexico have increased greatly, the future President Biden promised during his campaign to return to the Agreement and apply a new plan to combat climate change, with investments of up to US$ 2 million million, setting the target of achieving completely clean electricity generation by 2035. See DAVENPORT, CORAL: «Biden Pledges Ambitious Climate Action. Here's What He Could Actually Do». The New York Times. 3 December 2020. https://www.nytimes.com/2020/10/25/climate/biden-climate-change.html (Consultation Date, January 2021)

[32] COM (2019) 177 final

Energy policy in the European Union

The Treaties of Rome and the Liberalisation Directives

Energy has been present in the EU since it was created. In 1957, in Rome, the Treaty was signed that established the European Economic Community and the European Atomic Energy Commission (EURATOM) and it also included the Treaty signed years before to set up the European Coal and Steel Community (ECSC). The aim of the Treaty was to achieve economic and political cooperation between European countries (basically France and Germany at that time) enabling the signatory countries to access the benefits of free trade among each other. In accordance with the ECSC Treaty, coal, which was mentioned from the beginning of Europe as an autochthonous source of energy, should be allowed to move freely between the Community countries.

The Treaties constituting the European Communities only mention three common policies: the Common Agricultural Policy, the Common Transport Policy and the Common Trade Policy. Although the Treaties did not explain exactly what was meant by common policies, these were essentially defined by two characteristics. Firstly, the Communities had a sufficiently generous attribution of competences to enable them to intervene globally in these matters. Secondly, vocational intervention was high enough to bring about the virtual disappearance of the competition that the State originally exercised[33]. As a result, and in accordance with these constituent treaties, the way for European institutions to intervene in the Energy Sector was through its link to the Common Trade Policy or domestic market.

This orientation to the domestic market plus a concern over guaranteeing the security of supply were extended to energy as a whole, in the Merger Treaty of 1965 (the «European Community Treaty», ECT); a Treaty that embeds the initial Treaties, constitutes the Customs Union and consolidates the Common Market.

Two major events took place in 1973[34]:

- The Continental *Can* Ruling in which the Court of Justice of the European Union rules that, in the interpretation of the

[33] URREA, Mariola: «La política energética de la Union Europea a la luz del Tratado de Lisboa» Cuadernos de estrategia, ISSN 1697-6924, Nº. 150, pp.. 115-143. Instituto Español de Estudios Estratégicos. Ministerio de Defensa, 2011.

[34] https://europa.eu/european-union/about-eu/history/1970-1979/1973_es (Consultation Date January 2021)

provisions contained in the ECT, any company that occupies a dominant position and attempts to concentrate a degree of power such that it is in fact tantamount to the abolition of free competition, is incurring in an abuse of power.

– The holding of the Copenhagen European Summit, where prompted by the Oil Crisis, the Member States decided to implement a common energy policy and published a declaration on European identity, a result from several political cooperation agreements, that was approved by the Ministers of Foreign Affairs. It was above all an indication of European concern to guarantee the security of supply, by using autochthonous resources such as coal.

The Community's Energy Policy began to take shape over the next two decades, but it remained closely linked to the policy of promotion and defence of competition. The energy policy, for example, aimed at promoting certain electrical generation technologies, was going to be subsidiary to the national policies of each Member State. Hence, the defence, from the European institutions, of the privatisation processes and the introduction of competitiveness in sectors such as energy, which traditionally operated by means of monopolies.

This allocation of powers led, by virtue of Article 95 of the ECT regarding the approximation of legislations, to the approvement of the first electricity and gas Directives as a market liberalisation package. This package took the form of Directive 96/92/EC concerning common standards for the domestic electricity market and Directive 98/30/EC concerning common standards for the domestic natural gas market. Basically, these first gas and electricity Directives established free access to the transport and distribution networks, and the separation or unbundling between activities in competition and activities in monopoly. Furthermore, the National Regulatory Authorities (NRAs) were set up, as institutions that were independent both of governments and companies.

The way that Article 154 in the Maastricht´s Treaty of the European Union in 1992 (the «European Union Treaty», EUT) was expressed, indicated that «the Community will contribute to establishing and developing trans-European networks in the transport, telecommunications and energy infrastructure sectors». Thus, the development of trans-European networks is added to the supply security and competitiveness areas, in order to carry on filling the European Community´s Energy Policy with content. In 1995, the Commission published the White Paper «An Energy Policy for the European Union» in which it highlighted three key objectives: improving competition, security of supply and environmental protection.

The second package of gas and electricity Directives was passed and published in 2003. Its main effect was to increase the group of «eligible» consumers, for those consumers entitled to select a supplier through a competitive system, extending this right to all industrial consumers. In April 2009, approval was given to a third energy package whose intention was to liberalise the domestic electricity and gas markets to a greater extent. It made modifications to the second package and is regarded as the cornerstone of the creation of the internal energy market.

All in all, this whole set of Directives was lacking a common legal doctrine and they did not give rise therefore to creating a European Energy Policy in the real sense of the term, because there was a lack of clear distribution of decision-making and competence procedures in such important areas as fixing the energy mix for each Member State and the subsidy policy for certain energy sources.

The Kyoto Protocol and the Green Papers on Energy Policy

At the same time that this «rather undefined» energy policy appeared, in December 1997, the Kyoto Agreement was signed in the context of the UN Framework Convention on Climate Change, with the commitment to reduce Greenhouse Gas (GHG) emissions in 37 countries and in the European Union. The commitment consisted of a reduction of the emission by at least 5% compared to 1990, and to do so between 2008 and 2012, a period that was later extended to 2020; the EU accepting a target to reduce levels by 20%. Moreover, the Protocol set in motion the flexibility mechanisms or instruments for achieving the reduction goals accepted (joint implementation, clean development mechanisms and emissions trading rights).

The Commission's 1997 White Paper «Energy for the Future: Renewable Energy Sources» anticipates the Kyoto agreements and, in a certain way, it is considered to be the document that spawned the energy policy for promoting renewable energies in the European Union, given that it was to be followed immediately by the first Directives making reference to the promotion of renewables and setting indicative targets: These are Directive 2001/77/EC to promote renewable electricity in the domestic electricity market and Directive 2003/30/EC to promote biofuels in the transport sector. As a consequence, during the years 2000-2010, Europe has witnessed a change in the power generation mix that, although it has managed to reduce CO2 emissions in the Union as a whole, has yielded very different results in each one of the Member States[35].

The need to adapt the constituent treaties after more than twenty years had passed since its foundation, together with the enlargement of the European Community to 27 members, led to the Treaty of Nice, signed in 2001, which left the legal framework for European activities in energy matters almost intact, but marked the beginning of a series of actions, documents and communications from the European institutions, with proposals for coordinating the energy and environmental activities of the Member States. One of the first documents was the Green Paper «A European Strategy for Sustainable, Competitive and Secure Energy», 2006[36], which was followed in 2007 by nine communications issued by the Commission to the Council and Parliament concerning the generation mix (nuclear, hydrocarbons, biofuels and renewables), the domestic gas and electricity market and the strategic technologies plan. All these documents paved the way for the European energy plans included comprehensively in the European Energy Policy, referred to as such in the Commission's Communication of January 2007[37]. The First Renewables Directive in 2009[38] already set mandatory targets and made promoting the use of renewable energies a central issue within the Union´s energy policy and a key driving force for complying with the 2020 targets. However, at this first attempt, no legal instruments were provided that could require the «mandatory» targets to be fulfilled or that could make them effective.

The Treaty of Lisbon

The Treaty of Lisbon (Treaty on the Functioning of the European Union, TFEU) came into effect on 1 December 2009 and now

35 SOLORIO, Israel: «La política europea de renovables y su influencia en España y el Reino Unido». Estudios de Progreso. Fundación Alternativas. Nº 80, 2014.

36 COM (2006) 105 final

37 Directive 2009/28/EC

38 Directiva 2009/28/EC

contained a chapter exclusively devoted to Energy (Title XXI), according to which the Union had its own competence and capacity to act without having to resort to each one of the Member States. The Treaty refers to environmental protection, energy and trans-European networks as being among the shared competences, the aims of the Union's energy policy are constituted with a principle of a political nature, i.e. the principle of solidarity, becoming a legal obligation. The four objectives established for the Union's Energy Policy and whose measures are to be approved by a qualified majority, are: a) to guarantee that the domestic energy market functions; b) to guarantee the security of supply; c) to encourage energy efficiency and energy saving, as well as the development of new and renewable energies, and d) to encourage network interconnection.

The Treaty thus foresees a new decision-making process that incorporates the Union's ability to act into the energy policy and determines the residual power that corresponds to the Member States[39]. To be specific, Article 194(2) TFEU states that EU legislation will not affect each Member State's right to choose from among the different energy sources available and to decide what the general structure of its energy offer or mix will be.

This distribution of competences is of particular importance for the EGD. While the First Renewables Directive issued in April 2009 established a series of targets that were considered mandatory for every Member State, yet it lacked the means for enforcing these targets and penalising those who failed to comply, the Second Directive[40], passed after the TFEU had already come into force, was drawn up under completely different premises and complied with the Treaty's distribution of competences.

Clean Energy for All Europeans

The TFEU paved the way for the EU to adopt several legislative measures in 2018, aimed at implementing its medium-term strategy for reducing emissions; these came to be known as the 2030 Climate & Energy Framework. A year later, this Framework was incorporated into what was referred to as the Clean Energy Pack-

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[39] URREA, Mariola: *ibid.*

[40] DIRECTIVE (EU) 2018/2001 ISSUED BY THE EUROPEAN PARLIAMENT AND COUNCIL on 11 December 2018 concerning encouragement to use energy from renewable sources

age for All Europeans. The essential new pieces of legislation were the aforementioned Second Directive on renewables and the Regulation on Governance of the Energy Union & Climate Action[41]. A further six legislative instruments were added to the «package», concerning: energy efficiency, competences of the Agency for the Cooperation of Energy Regulators (ACER), the domestic electricity market (Directive and Regulation), building construction standards and treatment of risks in the electrical sector.

The goal set by the Framework and taken on by the Clean Energy Package was to reduce emissions by 40% when compared to 1990, and to reach 32% generated by renewable means and a 32.5% improvement in energy efficiency in the EU as a whole by 2030[42]. One of the biggest innovations of the energy policy formed by these strategic targets and these regulatory packages was the search for a balance, under the TFEU, between respect for the sovereignty of each Member State and the need to make the European energy policy targets and strategies implementable, even at national policy level. Thus, the goal set by the Framework for the renewable energy share out of the total energy generated is defined as a target for the Union as a whole, but it does not require each one of the Member States to comply with this limit individually. The executive obligations of each Member State are imposed not in the generation percentage, but in the area of governance. The Member States are required to commit themselves publicly before the rest of the Union, through National Energy & Climate Plans (NECPs) coordinated to make sure they are compatible with the global target. Furthermore, these must be periodically updated following the methodologies and guidelines established for that purpose. The Commission will assess each Member State's Plan, to check that it is consistent with the overall goal for the entire EU in 2030. The EU intervenes in boosting, coordinating, reviewing and approving these plans, which are mandatory. However, to «honour» what is contained in them and to materially comply with the goals established in them, falls within the sovereign «competences» of each Member

[41] Regulation (EU) 2018/1999 on Governance of the Energy Union and Climate Action.

[42] The upward review of these goals was anticipated by the Commission in the EGD [COM (2019) 640 final] and they were included in its proposal for a Climate Act [COM (2020) 80]. In its Resolution dated January 2020 [Text Approved P9 TA (2020) 005] the Parliament gave its support to the Green Deal and also backed the upward review of the goals. Finally, the objectives were reviewed by the European Council in December 2020 and the emissions reduction was raised to 55%. By no later than June 2021, the Commission will submit the legislative proposals to comply with these targets.

State. If they are not fulfilled, the State concerned will pay a political price, yet the State is «sovereign» from a legal perspective when it comes to establishing its own energy mix. The EU is thus trying to overcome the traditional difficulties that existed prior to the TFEU, which it came up against when it lacked the legal instruments that would make it possible to set goals and monitor compliance, all of which were discussed so much at the time of 2009 Renewables Directive.

Notwithstanding, this reformulation of competences in the TFEU and their application to the Union's energy policy, have caused a degree of division within the Union: on the one hand, there is a block of environmentally progressive countries led by Germany and Denmark, who are trying to encourage the adoption of ambitious targets while on the other hand, there is the group of Member States from Eastern and Central Europe, led by Poland, which opposes the adoption of ambitious targets for renewable energies, on claim that these will cause potential risks to their energy security, and in defence of their sovereign right to establish the composition of their energy mix.

All in all, if despite all its complexity and all the internal frictions involved, the EU´s energy policy after the TFEU were successful, this unusual combination of national competences (to quantify objectives) and European competences (to make requirements mandatory) would not have been alien to it and it would be highly likely that it could be exported to other supranational and multilateral entities[43].

The Green Deal as an axis of the European strategy

The new Commission appointed after the 2019 Elections, redefined the energy policy with an ambitious extension to its tar-

[43] Another example of this combination of targets that are binding on the Union as a whole while also respecting each Member State's «autonomous» competences, is the mechanism for financing new investments in renewable generation devised by the Commission and approved in September 2020. This mechanism makes it possible to allocate to the goals of a Member State (contributor) projects that it finance but which lie within another Member State (host), by means of a process of statistical allocation defined by the Commission in accordance with the fulfilment of the EGD's and the NRCP's targets. The mechanism integrates the financial contributions of all the Member States into a pool and then allocates them through a process of competitive auction that, for the purpose of fulfilling the joint renewable energy targets, enables all the participating States to benefit. See COMMISSION IMPLEMENTING REGULATION (EU) 2020/1294 on 15th September, regarding the Union's renewable energies financing mechanism.

gets, announcing a Deal consisting of «… a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use»[44]. This formulation is a leap forward when compared to the energy policy in the 2030 Framework and the Clean Energy Package. Implementing the policies included in the EGD and the strategies defined in previous years for the EU's energy policy are unfeasible if these are not carried out in the context of an international collaboration that accepts them and commits itself to their development. However, the Deal goes still further, and not only accepts that the EU must play an international leadership role in this process and obtain the support of the rest of the international blocks[45], but also broadens the European energy policy by defining as a broader objective, achieving a sustainable and circular economy by 2050.

Although it is not easy to find precise definitions of what a circular economy is, one of the main think tanks that is devoted to promoting and studying it, the Ellen MacArthur Foundation is of the opinion that promoting a circular economy *involves disassociating the economic activity of consuming finite resources and removing waste from the system from the outset. Backed by a transition to renewable energy sources, the circular model creates economic, natural and social capital and is based upon three principles: removing waste and pollution from design; maintaining products and materials in use; and regenerating natural systems*[46].

Therefore, the circular economy is a new economic and social model that, more than just through its intrinsic features, is defined as an alternative to the «traditional and linear economic model», which is the model that is operating in the Western world as we know it. To be more precise, this is defined in economiacircular.org as: *… an economic concept that interacts with sustainability,*

[44] This mention of a growth disassociated with the use of resources is responsible for the fact that the term «energy transition» has been transformed into the broader term «ecological transition», which appears in the Green Deal. COM (2019) 640 Final.

[45] On 10th September 2019 Úrsula Von der Leyen tweeted: «The European Green Deal has to become Europe's hallmark. I want Europe to be the front-runner. I want Europe to be the exporter of knowledge, technologies and best practice. At the heart of it is our commitment to becoming the world's first climate-neutral continent». https://twitter.com/vonderleyen/status/1171376907964813312 (Consultation Date January 2021).

[46] See https://www.ellenmacarthurfoundation.org/es/economia-circular/concepto (Consultation Date January 2021)

and whose objective is that the value of products, materials and resources (water, energy,…) is maintained in the economy for as long as possible, and that waste generation is reduced to a minimum. It is implementing a new economy, circular -not linear-, based on the principle of «closing the life cycle» of products, services, waste, materials, water and energy[47]*.*

Furthermore, the EGD is called upon to be the new European reference axis, displacing the integration of Europe as the centre of actions and strengthening Europe's global position in a *vis-à-vis* with China, Russia and the US, as well as multilaterally with respect to the world in general. However, formulated with such ambition, it has also aroused fears that it could end up by turning into the new «refugee crisis» and thus divide Europe, stirring up populism and nationalism within the Union[48]. At the end of 2019, the Australian Strategic Policy Institute considered that the EGD was so important in the EU's set of policies that the way it functioned in the coming years would either strengthen or break Europe and the Union. Because, in order to exercise the international leadership of this ambitious process it is essential to obtain internal support from among the Member States, and this support has to be strong and extensive enough to prevent the interests of some of States dominate, given that such prevalence could slow down the pace required to comply with the EGD in the Union as a whole.

Adding to the complexities arising from the very broad objectives and the new tools for implementation, a further complication has erupted since March 2020; this is the COVID-19 pandemic, the biggest disruption to affect the world since the outbreak of the Second World War.

The Green Deal: Objectives, Policies, Requirements and Consequences

Green Transition and COVID-19: The objectives

The COVID-19 upheaval caused an immediate nationalist backlash in the EU, placing each State as the citizens' first level of protection[49]. Strict controls preventing the free movement of

[47] https://economiacircular.org/wp/?page_id=62 (Consultation Date January 2021)
[48] LEONARD, Mark: «The Green Deal will make or break Europe» The Strategist – Australian Strategic Policy Institute. December 2020. https://www.aspistrategist.org.au (Consultation Date January 2021)
[49] COLOMINA, Carme: *Ibid.*

persons were imposed at internal frontiers, certain communities and regions were stigmatised and authoritarian measures were enforced, all of which seem to have revived internal crises that had already manifested themselves before in the form of North-South confrontations due to economic policies, or East-West confrontations arising from refugee and frontier defence policies. These initial reactions were a spontaneous response to the degrees of uncertainty created by the pandemic. Moreover, as a consequence of the uncertainty created, firms and consumers alike became more cautious and retained investments and expenditure on long-lasting consumer goods, depressing still further the aggregate demand levels that were already greatly affected by the health measures that were being taken[50].

Amongst the effects of COVID-19, it was expected that one would be to cause difficulties in the energy transition, mainly for three reasons: first, because it was a classic problem of collective action showing how difficult it was to control the free-riding behaviour that was abounding, not only at company and individual consumer´s level, but also at State and regional level; secondly, because it was going to demonstrate the importance of being able to count on strong support from citizens and on their education in order to deal with this type of problems; and; in the third place because this crisis would reveal how close a link there is between economic growth and CO2 emissions, and thus the costs involved in removing those emissions[51]. Furthermore, it would absorb financial resources in a situation where, in general, the world becomes more impoverished and the financing of the transition was competing with new and great needs for investment, not only in the area of public health, but also in the defence and sustaining of the traditional economic sectors.

Nevertheless, from the outset, public leaders, company directors and influential persons from research centres and think-tanks,

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50 VoxEU/ECPR: «Economic uncertainty in the wake of the COVID-19 pandemic», quoting BLOOM, N «Fluctuations in Uncertainty», Journal of Economic Perspectives, Spring, 2014 to review the economic literature that backs up this statement. https://voxeu.org/article/economic-uncertainty-wake-covid-19-pandemic#:~:text=Measures%20of%20economic%20uncertainty%20derived,thus%20necessitating%20forward%2Dlooking%20measures. (Consultation Date January 2021)

51 BORDOFF, Jason: Sorry, but the Virus Shows Why There Won't Be Global Action on Climate Change Foreign Policy. 27 March 2020. https://foreignpolicy.com/2020/03/27/coronavirus-pandemic-shows-why-no-global-progress-on-climate-change/ (Consultation Date January 2021)

Figure 1: European Green Deal. Source: EU Commission.

called for public and private mobilisation the world over, in order to obtain a resilient recovery, through a circular and sustainable economy, in response to the economic impact of the coronavirus. The approximately US$ 10 trillion (US$ ten million million) that governments decided to mobilise all over the world, according to the Club de Roma, constitute an unprecedented opportunity to «depart from a path of unqualified growth at any cost and from the old fossil fuel economy, to enter a long-lasting balance between people, prosperity and planetary limits»[52].

This strategy of post-COVID-19 economic recovery justified the fact that in September 2020 the President of the Commission, Ursula Von der Leyen, formally announced as a goal, a reduction in Greenhouse Gases (GHG) of more than 40%[53] when compared to the emission levels in 1990. The Member States must be able to use the 750 thousand million Euros from the recovery fund and the over one million million Euros (€1,073,000 million) from the

52 ELLEN MACARTHUR FOUNDATION: «The circular economy: a transformative Covid-19 recovery strategy. How policymakers can pave the way to a low carbon, prosperous future». 2020.

53 GHG emissions are gases released into the atmosphere that absorb and emit radiation within the infrared range. It is these gases that are mainly responsible for the greenhouse effect and the resulting global warming. The direct greenhouse gases are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6).

Multiannual Financial Framework (MFF) mostly to finance investments in ecological transition and in enhancing the production of renewable energies. Approximately 37% of all these funds will be earmarked for investments associated with the EGD. The first assessments made by the EU regarding the National Energy & Climate Plans (NECPs) indicate that, in general, the Member States are speeding up the process of transition and that the initial target of 32% renewable generation by 2030 might be exceeded and even approach 34% when this review ends.

Thus, one year after they were originally formulated, and despite the tensions and doubts initially created by the economic and social crisis, the responses given by the European institutions have been emphatic, making the EGD the backbone of their recovery strategy and providing it with a considerable volume of funds from the issuing of social bonds with joint European backing and a new MFF with its own new resources[54]. All these responses situate the EU at the dawn of a green transition that could enable it to realise its most ambitious project since its creation and consolidate it as epitomising an example of successful supranational institution, constructed on broader and more complex principles than any other institution belonging to the international order of the second half of the 20th Century.

The Green Deal Policies

A greater climate ambition

In March 2020, the Commission announced its proposal for a European Climate Law[55], with a view to raising the EGD's targets at a legislative level, and with the specific aim of making Europe the first climate-neutral continent by 2050. The Climate Law would thus mean a firm and legal commitment to the EGD objectives, to give a sense of security to investors, companies, citizens and the international community pursuant to the Green Deal.

[54] The framework for issuing European bonds backed by the Union as a whole, to finance the SURE Programme was approved by the Commission in October 2020 and the allocation of a new set of own resources for the Multiannual Financial Framework 2021-2027 was adopted by the European Council in December 2020.

[55] The Commission's proposal for a Climate Law [COM (2020) 80 final] was adopted by the Parliament in October 2020, to be debated with the European Council, which between October and December established its position to carry on with the EU's ordinary legislative process.

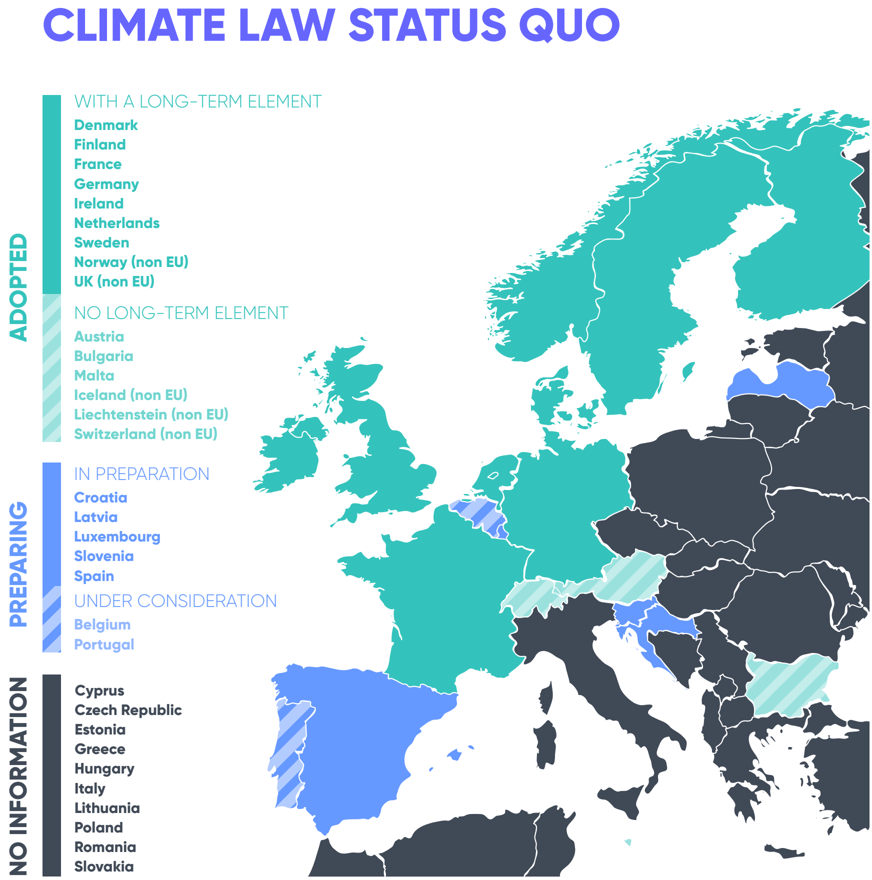

Figure 2. The Climate Law in different European countries. Source: Ecologic Institute and European Climate Foundation.

With a view to being consistent with recent European experience, the Climate Law seeks to attain its goals through governance standards, i.e., through detailed regulation of processes, and by their monitoring and control. The Law Project, in line with the TFEU and with what had already been established in the Second Renewables Directive and the Governance Regulation, proposes an effective governance system as a means for ensuring that every Member State complies with climate neutrality. The governance system would issue monitoring reports, proposals for corrective measures and a periodical review of targets, so they can be adapted every 5 and 10 years to the prevailing reality in each time period. The European Climate Law Project, thus finds itself in the area of legal standards approved by different European countries to establish multiannual and extensive frameworks of action that offer security and guarantees in the medium- and long-term, for complying with the Paris Agreement targets[56].

Supplying clean, affordable and secure energy

In view of the fact that energy production and use is responsible for at least 75% of the GHG emissions in the EU, the EGD seeks to reduce these emissions by promoting efficient energy, replacing fossil fuel generation with renewable sources, decarbonising gas and deploying new infrastructures such as smart grids, hydrogen networks, the capture, storage and use of carbon and the storage of energy.

Internally, the extent to which the different Member States comply with these targets will be controlled by monitoring the NECPs. The Commission will carefully examine the ambitions of the objectives proposed by each one of them, suggesting modifications and advocating new objectives if these prove insufficient.

The EGD also calls for greater transfrontier and regional cooperation, especially between the Member States, to obtain innovative infrastructures such as smart grids, hydrogen networks, the capture, storage and use of carbon, as well as energy storage, while at the same time making sectoral integration easier[57].

A great effort must be made by the Member States to cooperate, given the outdated and obsolete status of the European infrastructures. In recent years, European investment in grids and networks has remained stable, reaching almost US$ 50 thousand million per year. However, complying with the objectives of the EGD will require much greater volumes in the next few years[58].

Mobilising industry in favour of a clean and circular economy

The EGD realises that transforming an industrial sector and its entire value chain could take 25 years, a whole generation; so it is calling for immediate action to be taken over the next 5 years and for the percentage of recycled materials be raised considerably. The percentage currently stands at 12%. An industrial

[56] EUROPEAN CLIMATE FOUNDATION. «Climate Laws in Europe good practices in net-zero management». Ecologic Institute. NET ZERO 2050. February 2020. https://europeanclimate.org/net-zero-2050/ (Consultation Date January 2021).

[57] COM (2019) 640 Final.

[58] INTERNATIONAL ENERGY AGENCY: «World Energy Investment 2020». July 2020.

strategy and the New Circular Economy Action Plan[59] seek to decarbonise the value chains and use recycled materials, enhancing the circular and sustainable nature of the economy. One of the prerequisites is to guarantee the supply of sustainable commodities, especially those that are critical for clean technologies and digital, special and defence applications.

Efficient use of energy and resources in construction and renovation of buildings

Buildings account for 40% of all energy consumed and they are renovated at an annual rate that will at least double in the coming years in order to achieve the EGD targets. The materials utilised in construction will have to meet circular economy requirements and be conducive to «digitalisation and the ability of the real estate stock to adapt to climate change». Applying this energy efficiency policy to old and new buildings only seems to be feasible by applying two conditions: relative prices that include the cost of emissions in each material; and detailed regulations about the trading conditions for construction products and materials[60]. Both requirements involve production costs that could create imbalances not only between the suppliers of construction materials but also between regions. The IEA has detected and warned about these imbalances for the US $66 thousand million announced until October 2020 by the governments of the world, to be spent on measures associated with energy efficiency and as part of the supportive measures adopted in response to the COVID-19 pandemic. Europe is responsible for 86% of these public funds and the remaining 14% is divided between Asia-Pacific and North America[61].

Speeding up the transition to a sustainable and intelligent mobility

The target indicated by the EGD is a 90% reduction in emissions released by all types of transport between now and 2050. It is an extremely ambitious goal that requires measures to be taken that will affect all kinds of transport: land, air and sea.

59 COM (2020) 98 final.

60 The EGD announces the adaptation of EU Regulation n.° 305/2011, whereby standardised conditions are established for commercialising construction products and Directive 89/106/ECE issued by the Council is repealed.

61 INTERNATIONAL ENERGY AGENCY: «Energy Efficiency 2020». December 2020.

With a view to this, according to the EGD: «the Commission will propose increasing European emissions trading rights by applying them to the maritime sector and reducing the rights assigned gratuitously to the airlines in the EU´s Emission Trading Rights System. This will be coordinated with actions at world level, especially by the International Civil Aviation Organisation and by the International Maritime Organisation»[62]*.* In the short term, the Commission also sets as a goal for 2025 that nearly 1 million public charging and refuelling stations be provided for the 13 million zero-emission vehicles, basically electric cars, that are expected to be using European roads by then.

Energy consumption in the transport sector estimated for 2020 was 10% less than in 2019, and there was an 11% drop in crude oil consumption (around 6 million barrels per day). This fall is increasing energy use per passenger, but doubts surround the post-COVID effects, given that if travellers move from air to rail transport this will reduce energy intensity per traveller, whereas the opposite would happen if those passengers were to move to road transport. The IEA announced that convincing public policies will be needed, aimed at speeding up the electrification of transport so that there is no return to pre-pandemic behaviour[63].

From the farm to the table: a fair, healthy, and environmentally friendly food system

The EGD proposes linking the climate goals to the traditional EU´s agriculture & fisheries policy. The Deal is in favour of giving incentives to organic farming, agroecology, agroforestry and applying more stringent standards where animal welfare is concerned. Measures will also be taken regarding transport matters, storage, packaging, and food waste, while imported foodstuffs that do not comply with the EU's environmental standards will not be authorised.

In applying what is established in the EGD, in May 2020 the Commission announced its agricultural strategy, indicating the following targets:

- Reducing by 50%, the use and the risk of the most hazardous chemical pesticides.
- Reducing nutrient losses by at least 50%.

62 COM (2019) 640 final.

63 INTERNATIONAL ENERGY AGENCY: «Energy Efficiency 2020». December 2020.

– Reducing the use of fertilisers by at least 20%.
– Reducing the sale of antimicrobials for farm animals.
– 25% of agricultural land under organic production.

To reach these targets, the Commission proposes that the current regulatory standards are reviewed, that other new ones are implemented and that the tools for intra-community coordination are improved[64]. This coordination is essential if one accepts that achieving these goals requires «flexibility and adaptation to the actual situation in each Member State». Moreover, if this strategy is to be successful, it has to be compatible with keeping an agriculture and livestock sector competitive, so that it can compete against the rest of the countries. The only way to do this without raising barriers and limiting world trade is to find one «single regulatory framework without inequalities and with a set of rules of the game as similar as possible for all concerned»[65].

Conserving and restoring the ecosystems and biodiversity

After an initial call to the EU's «world partners» to put a stop to the loss of ecosystem biodiversity, which is to blame for natural catastrophes, plagues and diseases, the EGD announced a biodiversity strategy for 2030. In compliance with the announcement, in May 2020 the Commission made public the EU Biodiversity Strategy for 2030: bringing nature back to our lives. The following is stated as part of this strategy: «The EU is ready to show ambition to reverse biodiversity loss, lead the world by example and by action, and help agree and adopt a transformative post-2020 global framework at the 15th Conference of the Parties to the Convention on Biological Diversity». [66]

It initially accepts that something more than mere legislation is required to protect and recover nature. It proposes the following: that natural protected zones are created in at least 30% of the EU's land and sea surface areas; that land and sea ecosystems are recovered by limiting urban expansion; that invasive species are controlled; and that aggressive farming and fishing practices with a negative impact on the environment are stopped. It also

64 COM (2020) 381 final.
65 Declarations to the journal *Agricultura* by the leaders of agricultural associations on, 16 June 2020. Accessible at http://www.revistaagricultura.com/de-la-granja-a-la-mesa/economia/estrategia-de-la-granja-a-la-mesa-en-busca-de-una-solucion-armonizada_12078_39_15135_0_1_in.html (Consultation Date January 2021).
66 COM (2020) 380 final.

announces a proposal for binding targets in the area of nature recovery and a new monitoring and reviewing mechanism that will include a set of clear and consensually agreed indicators for assessing this monitoring process.

Aiming for zero pollution in an environment free from toxic substances

Under this heading, the EGD presents a set of actions that mainly affect local and regional authorities. The actions involve improving the quality of the air, groundwater and surface water, the soil and products for consumption. It announces a plan of action for attaining «zero pollution» that the Commission has to adopt in 2021. In June 2020, the Commission prepared a report for the Parliament and the Council concerning the progress made in implementing Directive (EU) 2016/2284 regarding the reduction of national emissions of certain pollutants into the atmosphere. The report is critical of what has been achieved in applying the Directive, the criticisms being levelled at form, content and substance. Only eight Member States submitted their National Air Pollution Control Programmes (NAPCP) on time, sixteen submitted them late, but before May 2020, two only submitted a draft by that date and two others (Greece and Rumania) had not submitted either a Programme or a Draft by the report´s publication date.

The Commission stated the following, about the Policies and Measures (PyM) included in the NAPCPs: «In general, the NAPCPs do not provide sufficient information about the PyM to definitely confirm their credibility; there is a particular lack of information about the planned adoption of PyM, the schedule for applying them and the level of emission reductions planned, Furthermore, with regard to about one third of the Member States analysed, there are some significant inconsistencies between the projections notified in accordance with Article 10, Section 2 of the Directive and those included in the NAPCP, which causes certain doubts regarding whether the measures proposed in the NAPCPs are suitable». In spite of all the above, the report was optimistic that the application of the EGD and the support given by the Union's financing programmes and funds would make it possible to achieve the Directive's targets, in view of the fact that the different initiatives proposed by the EGD (greater climate ambition, energy efficiency, developing renewables, etc.) will reduce the emission of pollutants and GHGs.

The Requirements

The EGD not only establishes the strategic targets and describes the set of policies and tools that can be used to achieve them, which have just been mentioned, the Deal also emphasises as needs or requirements that must be included horizontally in all these policies: 1) to bear in mind and make up for the social cost that might be involved; and 2) to be able to count on the financing required.

The EGD also mentions two pillars that lend it support and guarantee its success, namely: the consolidation of the EU as the world leader in promoting and applying environmental, climate and energy policies; and secondly enabling citizens to participate in drawing up and applying these policies through a European Climate Pact, in such a way that «the green transition occupies an outstanding place in the debate on Europe's future»[67], thereby clearly and explicitly linking the EGD's success to the future of the Union.

A Just Transition

Since the outset, the declaration announced by the EGD shows it is aware of the fact that if suitable supplementary social and economic policies are not adopted, the transition to climate neutrality could make the inequalities within the EU even greater, or even cause new inequalities and fail in a vital element, namely the support of the citizens of Europe and the unity of the Member States around this.

According to the Bruegel Report for the European Parliament[68], the idea of a just transition is historically deeply rooted in European institutions (Professional Recycling and Worker Relocation Fund in the framework of the ECSC and the European Social Fund within the Treaty of Rome). However, a more explicit formulation and the use of the term as such, entered the political debate through the Trade Unions in the US in order to give workers com-

[67] COM (2019) 640 final.

[68] CAMERON, Aliénor and CLAEYS, Grégory et al.: «A Fond for Fair Transition: the best way to put the European Union budget to good use to be conducive to the necessary transition from fossil fuels to sustainable energy». Report requested from Bruegel by the European Parliament´s Budget Commission. April 2020. Available at https://www.europarl.europa.eu/committees/es/supporting-analyses-search.html (Consultation Date, January 2021).

pensation for the loss of jobs as a result of environmental protection. After it became included in the annual debates of the Conferences of the Parties in the United Nations Framework Convention on Climate Change and the ILO's publication in 2015 of its «Guidelines for a Fair Transition», it was included in the preamble to the Paris Agreement in 2016. In the heart of the EU, the concept is based on several legal and political texts: ranging from Juncker's Energy Union package to the 2018 Governance Regulation[69].

The EGD includes a mechanism for a fair transition that seeks to support the sectors and regions most affected and exposed, so that nobody will be left behind. This mechanism endeavours to compensate the regions and sectors most affected, given their dependence on fossil fuels, including coal, peat and bituminous shale or GHG-intensive industrial processes. Some of these sectors will disappear, while others will be reduced and some will have to change, investing in alternative technologies that clean the emission-intensive processes[70].

In January 2020, the Commission proposed the Just Transition Fund (JTF) to support the regions most affected, and provided this Fund with €7.5 thousand million, which would be supplemented, within the Mechanism, by budgetary funds and by cofinancing with the Member States. This proposal was reformed and increased in May 2020[71] to adapt it to the Recovery Plan. At the meetings held between 17 and 21 July, the European Council agreed to a lower amount for the Recovery Plan and the Multiannual Financial Framework (MFF) 2021-2027, thus reducing the JTF, something that received strong criticism from the Parliament that in the plenary session on 23 July challenged the Council to

69 REGULATION 2018/1999 concerning governance of the Energy Union and Climate Action.

70 The coal infrastructure lies in 108 European regions with approximately 237,000 people working in coal-related activities, whereas almost 10,000 people are employed in peat-extraction activities and about 6,000 people are employed in the bituminous shale industry. COM (2020) 22 final. Proposal of RESOLUTION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL whereby the JTF is established.

71 After COVID-19, in May 2020, the Commission published a new proposal of Resolution jointly with the Parliament whereby the JTF is established and in its explanation of the reasons considers that «… in order to prevent the increase of disparities and an unequal recovery process, it is necessary to provide further support to the Member States and the regions in the short- and medium-term, with a view to helping their economies and societies to weather the situation , as well as to guarantee a rapid and sustainable recovery of their economies». COM (2020) 460 final.

justify the massive reductions made to the JTF budgets and to the «InvestEU» programme[72] in the context of the EGD, considering that it was a long-term European priority that should not be jeopardised. After the plenary session's resolution in September, the negotiations with the Council and the Commission about all the points —–except the financial endowment, which would be agreed on in the parallel negotiations about the MFF, according to a recommendation from the Parliament – should commence as soon as possible. In December 2020, the Parliament and the Council reached a political agreement about the Commission's proposal to endow the JTF with €17.5 thousand million, of which 7.5 will be charged to the MFF and 10 charged to the NextGenerationEU[73].

The mechanism will be supported by two more pillars, in addition to the JTF. As a whole, the Mechanism will consist of:

1) A specific fund for a Just Transition, run as a joint management system, which will focus on economic diversification in the most affected territories.
2) A specific system in InvestEU, that provides a guarantee charged to the Union's Budget, intended to support the investments and the access to EU financing for energy and transportation projects; and
3) A mechanism for loans to the public sector through the European Investment Bank (EIB) for general measures that facilitate transition to climate neutrality.

The characteristics considered suitable for this mechanism are that it must be promoted at a local level, it must include specific welfare and labour policies, must form part of a long-term strategy towards decarbonisation and the development of local economies, and it must allow for periodical assessments and modifications[74].

[72] InvestEU is a European programme that, following the Investment Plan model under the Juncker Plan, brings together a series of European funds to mobilise public and private investments with the guarantees covered by the European budget. It consists of a hub for providing consultancy services and support for projects that seek financing, a database accessible for investors and projects and the aforementioned guarantees charged to the European budget.

[73] Next GenerationEU is a temporary recovery instrument that came into existence endowed with €750,000 million to contribute to repairing the economic and social damage caused by the coronavirus pandemic. Together with the MFF, finally adopted on 17 December 2020, it constitutes a total of €1.8 million million earmarked to reconstruct a Europe that will be more ecological, digital and resilient.

[74] These characteristics must be developed in the regulation concerned, and so far only constitute the opinion of the Bruegel Report, stated in CAMERON, ALIÉNOR and GRÉGORY CLAEYS et al. *Ibid.*

Mobilising the finance required

If establishing the JTF endowments to finance the just transition was only possible after hours of discussions and negotiations throughout 2020 in the heart of the European institutions, reaching an agreement regarding the suitable framework for moving all the financing needed to cover the requirements of the EGD would also appear to be a difficult task. It is estimated that every year, the investments associated with the EGD will reach 1.5% of the EU's GDP (16% in 10 years until 2030). This will amount to between 175 and 290 thousand million Euros of extra investment per year during the coming decades; this means that the current financial instruments, not only the UE's but also the EIB's, the capital markets, the private banking and other financial institutions, will be subjected to considerable stress, as they will have to attract more resources and there will probably be major reallocations in their relative weight[75]. This investment will have to be covered with both, public resources, charged to the budgets of the Union and the Member States, and by means of private resources provided through different financial instruments.

After March 2019 and once the EGD had become the backbone of the European recovery strategy, the agreements reached in the Commission, the Parliament and the Council at the end of 2020 will mobilise in the next few years, a volume of resources charged to the EU budget that will be «the largest ever financed»[76]. More than 30% of these funds will be allocated to combat climate change, being added to the public and private resources needed to finance the EGD, which are calculated to be around 260,000 million Euros per year, for each one of the years from now to 2030 (about 2.6 million million Euros in the next 10 years).

To reach this amount, the EU will have to make an effort in defining the different financing modes to be utilised and in mobilising them. Regarding the public part for which the EU is directly responsible, the €1.8 billion will be obtained by combining, for the first time in its history, loans obtained on the financial markets backed by the EU as a whole, with its own taxation resources, obtained directly from firms and citizens (frontier adjustment

75 See LEHMAN, ALEXANDER and BRUEGEL: *Ibid.*

76 As has already been pointed out, the package amounting to a total value of €1.8 billion (€1.8 million million) includes 0.75 billion from the NextGenerationEU recovery fund and 1.074 billion from the MFF 2021-2027 https://ec.europa.eu/info/strategy/recovery-plan-europe_es

mechanism for carbon emissions, digital tax, emission rights system, financial transactions tax and a new common taxable base for the corporate tax). The Member States will be responsible for part of the rest (about €114,000 million) and another part will necessarily have to be financed through private capital, albeit with aid or guarantees from the EIB, or with some kind of public support for covering the risks associated with the investment.

Moreover, the EU is considering several initiatives and regulatory instruments to encourage private investment and channel it towards the EGD targets:

- The first initiative is to have a taxonomy, i.e. a means for classification, or a set of consistent criteria for being able to determine whether or not a particular economic activity can be regarded as environmentally sustainable for political, industrial and investment purposes[77].
- The second one is to improve the obligation that the creators of financial products, their advisors and distributors have to inform about the impact of environmental sustainability on financial profitability and the risks affecting the financial products they issue, give advice about or distribute[78].
- The third consists of regulating the reference indexes that inform about the carbon impact of investment portfolios and financial products that can be sold across frontiers: these indexes are grouped into those that inform about the climate transition in the EU, and those that inform about compliance with the Paris Agreements[79].
- Other initiatives that have still not taken the legal form concern fostering international cooperation, establishing a standard criterion for issuing green bonds[80], requiring the financial

[77] In May 2018, the Commission published a proposal of Taxonomy for grading green projects. In 2019, an experts' report was issued on the criteria for establishing this taxonomy of sustainable products; i.e., *…a list of economic activities rated and classified on the basis of the contribution they make to the aims of the EU's sustainability policies*. In December 2019, the European Parliament and the Council agreed to go ahead with a Regulation of the Taxonomy. The Regulation was ultimately approved on 18th June 2020: REG (EU) 2020/852.

[78] REG (EU) 2019/2088

[79] REG (UE) 2019/2089

[80] Green bonds are bonds issued by a variety of institutions (firms, banks, local bodies, governments, etc.) to finance investments in assets that comply with certain requirements, for improving the environment; the best-known of these instruments are the Green Bond Principles (GBPs) of the International Capital Market Association (ICMA). https://www.icmagroup.org/sustainable-finance/ (Consultation Date January 2021).

institutions to take into account their clients' preferences as far as sustainability is concerned, improving the transparency of the companies' public information and incorporating sustainability into the integration of the risks involved in the financial decisions and into the need to adapt the caution criteria in the treatment of assets[81].

In November 2020, the IEB gave its approval to a roadmap to be implemented between 2021 and 2025, for turning the bank into a genuine climate bank where its investment programmes are concerned. To attain this, it will give its support to investments in climate action and environmental sustainability amounting to €1 trillion in the decade until 2030. All its activities as from the end of 2020 will be aligned with the objectives of the Paris Agreement. The Bank hopes that in 2025 more than 50% of its financing programmes will be earmarked for green investments. Consultancy and financing services rendered for low-emission technologies will increase and it will give its support to the green financial product markets, adapting them to climate change and to projects included in the JTF.

One of the most widely used financing sources, not only in the EU but also in the rest of the world, has been green bonds[82], since in 2009 the World Bank launched the first issue of these bonds. The problem is that in the initial years, the criteria for entitlement to issue green bonds were too extensive and concerned the individual projects rather than companies, which would have prevented making up for the reduction of emissions in a specific

[81] These mechanisms are currently under study and are being submitted to public consultation process. One of the proposals consists of relaxing the financial institutions' capital obligations to back green credits, including those allocated to making improvements in building efficiency. However, the Bruegel European think-tank is highly critical of these types of support mechanisms, given that it thinks they are not effective and not sufficiently justified because of the problems of moral risk and the incentives to undervalue risks that they might cause. See LEHMAN, ALEXANDER and BRUEGEL: «European green finance is expanding, a discount on bank capital would discredit it». Blog Post 15 January 2020. Accessible at: HTTPS://WWW.BRUEGEL.ORG/2020/01/EUROPEAN-GREEN-FINANCE-IS-EXPANDING-A-DISCOUNT-ON-BANK-CAPITAL-WOULD-DISCREDIT-IT/ (Consultation Date January 2021).

[82] In October 2020, the journal Funds&Markets stated: *At present, the world market for green bonds -bonds that are similar to the traditional ones but that are used to finance projects with environmental benefits -, amounts to around €662,000 to 672,000 million and this figure is expected to rise to € one billion by the end of 2021 and to 2 billion by the end of 2023, according to calculations made by NN Investment Partners*. https://dirigentesdigital.com/bolsas-y-mercados/el-mercado-de-bonos-verdes-alcanzara-los-dos-billones-de-euros-en-tres-anos (Consultation Date January 2021).

Figure 3: Main lines of work for the EIB's roadmap to becoming a Climate Bank. Source: EIB.

area or activity with an increase in other adjacent areas or activities, could it be for the same emitting company[83]. In June 2019, concern over the need to have more clearly defined standards, led a group of EU experts (TEG) to publish a report, at the Commission's request, recommending a European standard to classify the assets whose financing would be considered eligible for green bonds. The report proposed this standardisation with a view to improving transparency, effectiveness, comparability and credibility in the Green Bonds Market[84].

Geopolitical consequences of the EGD

The consequences of such an ambitious programme as the European EGD are considerable and difficult to pinpoint with a complete and detailed list. Yet, once the objectives, policies and requirements of the EGD have been described, it is advisable to

[83] EHLERS, TORSTEN and BENOIT MOJON and FRANK PACKER: «Green bonds and carbon emissions: exploring the case for a rating system at the firm level». BIS Quarterly Review, September 2020.

[84] This Report from the Technical Expert Group (TEG)´s Commission, issued in June 2019, contained certain recommendations that the TEG itself used to prepare a «Use Guide» in March 2020, and in June 2020 the Commission launched an Initial Impact Assessment and a public consultation to evaluate whether they should begin work on a legislative initiative to be implemented throughout 2021 and 2022.

mention some of the programme's main consequences, which will affect not only the EU's relations with other world power blocks, but also the internal relations between the EU's Member States. This description will give us an idea of the scale and the difficulties involved in applying this strategic axis of European policy, doing so from a geopolitical perspective. It will also give us insight into its ability to transform and its potential for mobilising, when attempting to achieve a world that is sustainable and balanced, which can lead us away, at least in the immediate future, from a path towards potential self-destruction.

Reinforcing international financial flows

So far, the green financing experience in the world is ambivalent, showing successes and failures. At the 2009 meeting in Copenhagen, the OECD´s developed countries promised US$100 thousand million per year to the countries in the South, for clean energy development projects. However, in the seven years between 2010 and 2016, the investments of these developed countries in foreign countries, including the developing countries, only reached US$112 thousand million throughout that seven-year period[85].

It is calculated that annual investments of nearly US$1 trillion will be needed to finance the world's green transition. In 2017 it was estimated that investments in infrastructures for energy, transport, drinking water and sanitation, together with telecommunications, over the next 15 years, would have to reach US$80 to 90 trillion. These investments are basically long-term risk assets that are intensive in the use of capital, so they have long maturity periods that will be difficult to meet at the start of the green transition, especially by private financial institutions, since they usually have investment opportunities that are just as profitable or more profitable, with more liquidity, shorter maturity dates and, therefore, with apparently less risk.

Financing the investment volume demanded by the energy transition will not only need public support policies and regulations that remain stable in time, but will also need specialized institutions. The public Development Banks (generally local) that provide cofinancing for these investments, especially during the first

[85] HARRIS, Jerry: «Can China's Green Socialism transform global capitalism?» Civitas, Porto Alegre, v. 19, n. 2, P. 354-373, May-Aug. 2019. https://doi.org/10.15448/1984-7289.2019.2.31972 (Consultation Date, January 2021)

years of the transition, are specialising in investments of this type[86]. However, what is needed is a global institutional mobilisation. According to the United Nations, it will only be possible to finance the resources required if multiple and diverse agents, financial markets, banks, private investors, insurance firms, the public sector, etc., are involved.

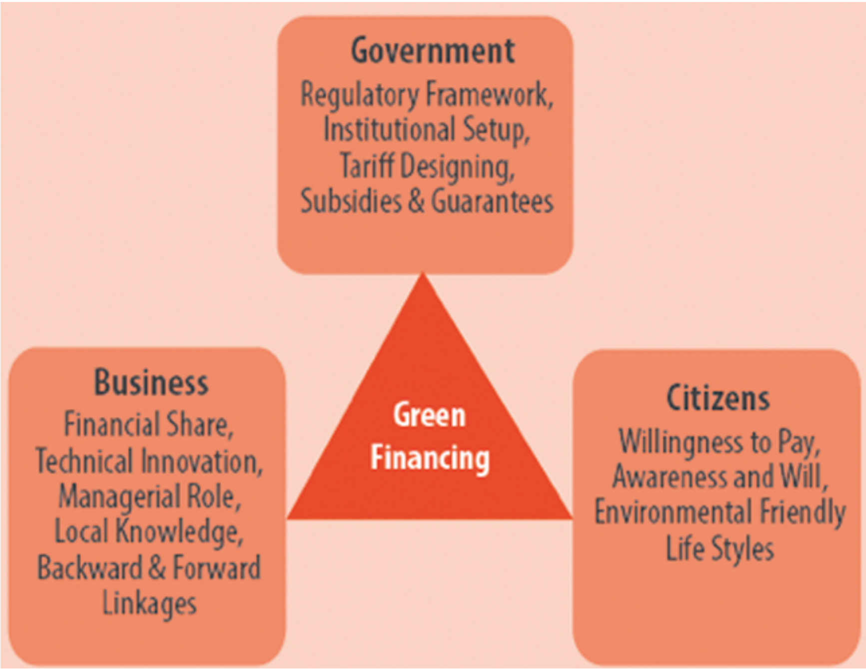

Figure 4: Stakeholders in green financing. Source: UN Environment Program. https://www.unenvironment.org/regions/asia-and-pacific/regional-initiatives/supporting- resource-efficiency/green-financing.

In recent years, the Chinese experience in mobilising financial resources allocated to supporting the green transition and the Sustainable Development Goals is one of the most outstanding examples. Chinese companies (state and private) have been the most active when it comes to issuing green bonds. Between 2010 and 2020, 172 issuances of green bonds were registered amount-

86 XU, Jianjun and KEVIN P. GALLAGHER: «Leading from the South. Development Finance Institutions and Green Structural Transformation». Global Development Policy Center (Boston University) and The Center for New Structural Economics. CEGI Policy Brief. October 2017.

ing to US$10.4 million[87]. China has been leading these issuances, accounting for approximately 40% of the total. In September 2016, the People's Bank of China (PBC) published its guide to establishing a Green Finance System. It was the first time anywhere in the world that guidelines of this type were published. However, it must be pointed out that the Green Bond Catalogue, endorsed by the PBC, includes the «clean use of coal» and, during the first half of 2019, the Chinese financial institutions provided funds for a value greater than US$ one thousand million for coal projects, described as green by their own standards[88]. All in all, the estimates made by the PBC regarding the investment needs in China for projects associated with emission control and climate change mitigation range from US$310 to 620 thousand million per year for the next few years[89].

Although this entire financial mobilisation will be received favourably as long as the interest rates are low, there will also be difficulties and risks. Apart from the traditional macroeconomic barriers, such as exchange rate volatility, possible inflation, capital controls and GDP growth rate volatility. Fiscal disciplines often prevent the provision of the public funds that are necessary to support the first years of the transition. In some developing countries and in emerging markets, access to international financial markets is difficult and fraught with constraints, while the local markets do not offer sufficient maturity to cope with these long-term investments. In addition to all these risks, there are also political risks such as a lack of institutional stability, regulatory risks and distorting policies[90].

Moreover, should the announced quantities of funds needed for green investments be mobilised, the world debt will continue to rise, to the extent that world investments continue to be greater

[87] INTERNATIONAL FINANCE CORPORATION: «Green Bond Impact Report Financial Year 2020». World Bank Group. October 2020.

[88] The international standards for qualifying an issuance as being a «green bond» issuance do not include those earmarked for financing coal projects. https://chineseclimatepolicy.energypolicy.columbia.edu/en/green-finance

[89] As described in the preceding section, the European experience has been aiming at obtaining a stricter common taxonomy and a set of regulations concerning information and risks so that green financing can guarantee the EGD goals and specifically that the financing is allocated to obtaining real incentives to reduce emissions. To achieve this, what probably makes more sense is to establish standardisation by companies, rather than by projects. EHLERS, TORSTEN and BENOIT MOJON and FRANK PACKER: *Ibid.*

[90] BERENSMANN, Kathrin et al.: «Fostering sustainable global growth through green finance – what role for the G20?». G20 Insights. 12 April 2017.

than the savings levels. Four years ago, the IMF calculated a total world non-financial debt amounting to US$152 million million, equivalent to 225% of the world GDP. According to the same source, and considering the expectations existing before the irruption of the COVID-19 pandemic, the average debt in 2020 would grow by 17% of the GDP in the advanced economies, 12% in the emerging economies and 8% in the countries with the lowest income[91]. In a report on the fiscal situation of the world economy issued in October 2020, the IMF estimated that, in the whole world, around US$12 trillion had been spent on «cushioning the blow» caused by COVID-19. Nearly all the economies in all the countries the world over relaxed their budget restrictions and, at least 30 countries, face a debt greater than 100% of their GDP. As has already been pointed out, this world debt explosion coexists with interest rates that have historically never been as low, that, for some considerable time (approximately since the years following the financial crisis of 2007-2008), are being sustained together with expansive monetary policies by the Central Banks. Although in the short-term maintaining these monetary and fiscal policies may keep prices stable, in the medium- and long-term, only the success in terms of economic growth of the current recovery programmes – and specifically in the EU the Recovery and Resilience Programme,[92] closely linked to the EGD – can offer certain security to an absorption or renegotiation of the current debt levels without causing hyperinflation, restructure or a multiple default.

New framework in trading relations between power blocks

Article 3 of the TFEU establishes that the Union has exclusive jurisdiction over the Common Trade Policy. This Policy is exercised through bilateral agreements with other countries as a counterpart or unilaterally through the institutional framework of its own regulation[93]. In recent years, the international trade in goods and services in this institutional framework has reached records in both volume and economic weight, and the EU has

91 https://www.imf.org/en/News/Articles/2020/10/01/sp100120-resolving-global-debt-an-urgent-collective-action-cause (Consultation Date January 2021).

92 https://ec.europa.eu/info/strategy/recovery-plan-europe_es (Consultation Date January 2021).

93 For example, Regulation (EU) 2015/478 concerning common rules for imports and Regulation (EU) 2015/479 concerning common rules for exports.

played one of the main roles. In the EU-27, imports and exports of goods with other countries (excluding intra-community trade) almost doubled between 2009 and 2019[94]. In 2019, China, the USA and the EU accounted for 42% of the total world exports of goods and 43% of the total imports. In foreign trade, the EU 27 had a fairly balanced coverage ratio, with slight deficits in 2018 and surplus in 2019. China and Russia had the greatest surpluses, whereas the USA, the UK and India were the countries with the largest deficits[95]. The importance of these trade flows to economic growth has been stressed in traditional economics literature, such importance being based on the theory of the comparative advantages that some countries have over others[96]. Yet this theory ceases to be valid in a world with externalities, as is the case when costs are incurred from protecting the environment and combatting climate change.

The upward trend in trade has been temporarily interrupted by the effects of COVID-19, which were observed especially in the months of March, April and May 2020, a slight recovery being detected as from June. Trade was directly affected by COVID-19 because of the export bans and the restrictions that were applied to medical equipment/healthcare material such as test kits, masks and protective equipment. The EU, specifically the Commission, has been trying to ensure that these measures do not affect intra-community trade, although this has not always been successful[97]. The indirect effect was a general downward trend in economic activity, as can be seen in Figure 5.

94 In 2009, exports stood at 1,184 thousand million Euros and in 2019 reached 2,132 thousand million Euros. Goods imports rose from 1,193 in 2009 to 1,935 thousand million in 2019. International trading of services accounted for one third of the figure for goods. EUROSTAT: «International Trade in Goods» Statistics Explained. 14 October 2020. https://ec.europa.eu/eurostat/statisticsexplained/ (Consultation Date, January 2021).

95 EUROSTAT: *Ibid.*

96 In 1817, the economist David Ricardo explained that international trading advantages stemmed from the fact that countries tended to produce and export those goods and services in which they used less relative resources, importing the rest, thereby being conducive towards global welfare. This basic idea has given support to many international trade studies, but it has also been criticised because it is based upon hypotheses that are not very realistic, such as for example the perfect mobility of the production factors, the absence of financial expenses and, above all, and this is what is of interest to us regarding international trade that is compatible with the EGD, that there are no externalities whatsoever.

97 PIRKER, Benedikt: «Rethinking Solidarity in View of the Wanting Internal and External EU Law Framework Concerning Trade Measures in the Context of the COVID-19 Crisis». European Papers Vol. 5, 2020, No 1, Page 573-585 (European Forum, 25 April 2020).

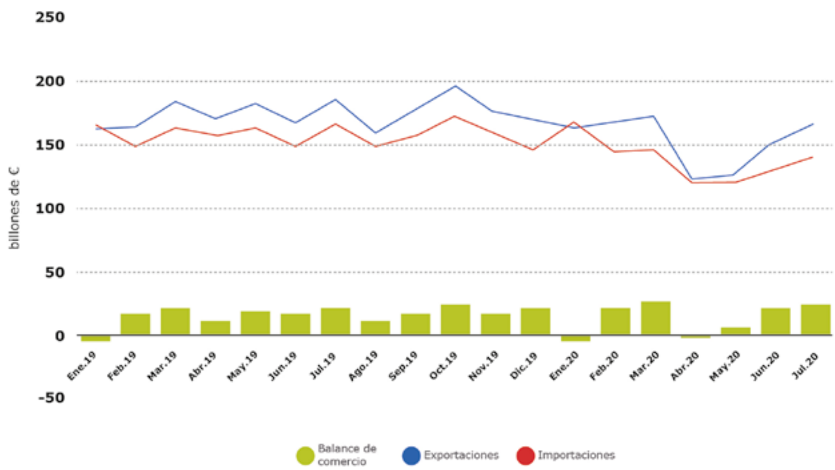

Figure 5: Goods imports and exports in the EU 27.

COVID-19 has also brought to light the plight affecting the EU's current trading institutions and the difficulties of the international order when it comes to finding globally supportive and cooperative solutions. It is true to say that the world trade institutions were already questioned before COVID-19. The EU was being left relatively alone in their sustainment. The Organisation for Economic Cooperation and Development (OECD), the International Standards Organisation (ISO), the World Trade Organisation (WTO) and the General Agreement on Tariffs and Trade (GATT) have been issuing standards supporting the opening up of trade for more than 70 years, ever since the GATT was established. Upon such background, the EU Member States have been particularly active within these institutions. It is to be hoped that not only the Member States but also the EU institutions (Commission, Council and Parliament) will keep up this level of activity and leadership and that they will work with their closest allies towards obtaining a new international trading framework that is compatible with the emission-neutral sustainable growth sought after by the EGD[98].

China´s escalation and the US's perception that the set of rules prevailing in the trade order did not guarantee a balance compatible with the US's interests, prompted the Trump Administra-

[98] WOOLCOCK, Steve: «The Role of the European Union in the International Trade and Investment Order». Discussion Papers. Nº 2019/02. Jean Monnet Centre of Excellence in International Trade and Globalization. The University of Adelaide. 2019.

tion to abandon trading multilateralism represented above all by the WTO, this action being one of the key features of Trump's Government. China could certainly have been able to exploit the advantages of «free» trade, as the country is a «non-liberal» one, and the country's sharp growth has served as a flag «for countries disappointed with the European and American model of liberal democracy»[99]. That is why it is hardly surprising that the Trump Administration viewed international trade as a scenario that enabled China to obtain advantages over the US. However, it is also true to say that this view has been criticised from the US as being excessive, given that it does not consider the economic benefits of helping the national economy to become more export oriented, while at the same time offering consumers more options at a lower cost and keeping the domestic inflation rates low[100].

Moreover, the concentration of materials in the hands of just a few producers, as in the case of Rare Earth Elements (REE), and their geopolitical use, cause world prices to be susceptible to instability and can lead to price bubbles that transfer inefficiencies to public policies and to private investment decisions. By 2028, lithium and graphite anodes production are expected to increase ninefold when compared to the 2017 levels, cobalt production is expected to increase fivefold and nickel production is likely to go higher than a fivefold increase to cater for the expected rise in demand for electric vehicles[101]. It is very unlikely that such a scenario will be compatible with stable prices and geopolitical balance, even less so if the multilateral international trading institutions are still weak.

All of this begs the question of whether the geographical concentration of raw materials that are indispensable for the technologies required by the green transition, will play in the future a role similar to the one played by the OPEC, and will give rise to a new organisation of REE exporting countries trying to control the world market in these materials and trying to use them as a way of exercising power. From a geopolitical perspective, the

[99] ECONOMY, Elisabeth: «The Third Revolution. Xi Jinping and the New Chinese State». Oxford University Press. May 2018.

[100] HAASS, Richard: *Ibid.*

[101] OXFORD INSTITUTE FOR ENERGY STUDIES. «Electricity, Electric Vehicles, and Public Policy: Eight Key Takeaways». Second workshop on the impact of disruptive change in the transport sector. Takeaways compiled by Anupama Sen, Senior Research Fellow. February 2019.

power will lie in possessing and exploiting these raw materials or in dominating the technology, holding the patents and controlling the know-how, all of it essential for extracting these elements and giving value to them. Yet this hypothesis must be qualified. The extent to which there could be a geopolitical risk due to a geographical concentration of REEs, depends on whether there will be alternatives that can be used to replace the rare earths currently being utilised for renewable energies. For example, it is unlikely that lithium, which is used in electric batteries, will be affected by unlimited price explosions in the future, because batteries can be replaced as means for storing electricity (energy cells or, for high power solutions, the hydraulic alternative). This hope is based on the idea that the demand for REEs will not prove to be as rigid as the demand for fossil fuels has been in recent decades, so the exporting countries will be able to wield much less geopolitical power[102].

The EGD, as it has been formulated by the EU, is a window of opportunity that is particularly suitable for laying new foundations on which to consolidate the international trade order and modify the current institutions, especially the WTO and the GATT. The inclusion of clauses regarding compliance with the Paris Agreements and possibly other clauses concerning the Carbon Border Adjustment Mechanism (CBAM) make it necessary to adapt the trading rules to the progress of the EGD. If the EU wishes to lead the green transition it must turn the trading policy into one of the main instruments for this transition. To do this, the Commission «…will use its economic influence to draft international standards that are in keeping with the EU's environmental and climatic ambitions»[103]. International cooperation and multilateralism are essential if the EGD's goals are to be achieved. The European ecologist sectors argue that the order of priority for approaching this international cooperation from the EU must be reversed: it must first serve to guarantee compliance with human rights and protecting citizens and the planet, and in doing this promote and encourage trade, not the other way around[104].

102 MÄNBERGER, André and BENGT JOHANSSON: «The geopolitics of metals and metalloids used for the renewable energy transition». Energy Strategy Review 26. Elsevier. (2019).

103 COM (2019) 640 final.

104 DUPRÉ, Mathilde: «European Trade Policy and the Green Deal». Green European Journal. 17 March 2020. Accessible at https://www.greeneuropeanjournal.eu/ (Consultation Date, January 2021).

In view of the fact that the EU could hardly be described as a commercial superstate like China or the US, its trade policy is constructed on the basis of it acting as a multilevel and supranational organisation. Therefore, its experience has to be very «exportable» for the construction of international trading rules that make it possible to include in international contracting, the external costs incurred as a result of the green transition and climate change policies.

Nationalism in the electrical generation mix

The five years following the Paris Agreements have witnessed a major increase in installing renewable generation plants all over the world. However, their combination with energy provided by fossil or nuclear fuels ranges greatly from one country to another, even within the EU. Europe has risen from 322 GW renewable generation installed in 2010 to 574 GW in 2019. In photovoltaic solar energy alone, the annual installed capacity increased twofold, rising from 8.2 GW in 2018 to 16.7 GW in 2019. As has already been mentioned, Article 194 of the TFEU establishes that the energy mix is the exclusive competence of each Member State, so the targets for renewable facilities taken on by the EU are mandatory for the Union as a whole, but not specifically for each individual Member State.

What is more, by deploying renewables, the EU has sought to use its influence, its technical expertise and its financial resources to mobilise its neighbours and partners and get them to join forces. The fact of the matter is that between 2010 and 2018, generation from renewable sources rose in the world by around 2,000 TWh/year[105] and in the last ten years, the installed capacity for renewables practically doubled, and in Asia the figure tripled during this period. IRENA defined this growth process affecting renewables all over the world as unprecedented for generation by wind, sun and other renewable sources,[106] yet despite these promising beginnings, there is a less optimistic side to the matter that might affect its continuity.

[105] https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Regional-Trends

[106] It also accepted that: «Innovations affecting digitalisation and energy storage are increasing the potential for renewable energies to prosper in a way that was unimaginable just a decade ago». IRENA. «A New World: The Geopolitics of the Energy Transformation». Global Commission on the Geopolitics of Energy Transformation. 2019.

China, where promoting renewables commenced with the 2005 Renewable Energies Act, doubled its installed wind capacity annually from 2006 to 2008. Even so, the Chinese commitment is ambiguous because it does not renounce anything: 1) despite its spectacular increase, the share of renewables in the total installed capacity has fallen, whereas the total traditional thermal generation with coal has risen. Between January 2018 and June 2019 it grew by 42.9 GW, when it fell in the rest of the world by 8.1 GW[107]; 2). many wind generation facilities are not connected to the grid, so their generation is frequently wasted; and 3) their energy efficiency is poor (the generation produced by each MW of installed capacity is very low)[108].

The year 2019 was the first ever in the US that generation by renewable sources exceeded coal-generated sources. Despite Trump's pro-hydrocarbons stance, in June 2019, 29 States plus the District of Columbia had clauses in force requiring them to obtain a certain proportion of renewable energy in their energy purchases (Renewable Portfolio Standard or RPS) or other similar policies supporting green energies. A further eight states had applied voluntary schemes to promote these energies[109]. The commitment of these States, especially California, in the face of an erratic federal policy, has sustained the growth of renewable energies in the US in recent years.

Yet the increase in renewable generation in the EU has not led to a convergence in the combination of electricity generation costs between the Member States. In 2018, the energy mix in the EU basically consisted of five technologies: Oil and derivatives (36%), natural gas (21%), solid hydrocarbons (15%) and renewable energy (15%) and nuclear (13%). Being an average mix, there were major differences from one Member State to another. For example, nuclear energy accounted for 42% of the total in France and 32% in Sweden. The percentage of coal amounted

107 More data: Chinese firms are committed to constructing about 700 coal plants, of which 20% will be built beyond its frontiers. Since 2001, China has participated in 240 coal based thermal generation projects in 25 countries, many of them in the framework of the One Belt One Road Initiative (OBOR) proposed in 2013. HARRIS, Jerry: *Ibid.*

108 WANG, Feng and HAITAO YIN and SHOUDE LI: «China's renewable energy policy: Commitments and challenges». Energy Policy 38. 1872-1878. April 2010.

109 ENERGY INFORMATION ADMINISTRATION: «Portfolio standards: What are renewable portfolio standards?». Renewable energy Explained. https://www.eia.gov/energyexplained/renewable-sources/portfolio-standards.php (Consultation Date January 2021).

to 47% in Poland and 72% in Estonia[110]. Natural gas accounted for more than one third of the energy produced in Italy and the Netherlands. This lack of uniformity leads to major differences in the electricity supply generation costs of each Member. State, and hence to disproportionate production costs for the goods and services that use electricity for their production, especially in those goods and services that use electricity intensively. Such disproportions give rise to very different interests and positioning from one Member State to another with respect to the rate at which traditional technologies are replaced by renewables. The EGD will have to live with these differences and try not to cause «nationalistic» resistances when it comes to replacing «dirty» technologies with clean ones, distancing itself from the targets indicated for the Union as a whole.

As intermittent generation depending on climatic factors as the sun and wind increases, the composition of the electrical system cost function will change and new inequalities will emerge between combinations of different technologies, whose long-term convergence can only come from an economically efficient combination of green technologies, zero-emission backup generation and an active demand with a considerable storage capacity. Until then, nuclear generation[111] and natural gas seem to be energy sources that can coexist and adapt to the rate of change that is imposed by the Union as a whole and by each Member State individually, which is unlikely to be the same in different zones of the Union.

The deployment of renewables is also making it necessary to carry out major changes in the energy spot markets developed in the EU during the 1990s and 2000s. Daily prices have not proved to be good benchmarks for investment purposes and are too volatile to simultaneously remunerate backup technologies (with high variable costs) and renewable technologies (with a low variable cost, almost zero). The EGD, which considers efficient energy consumption to be a basic objective, needs the electrical sector to change from a situation in which it is generation flexibility that responds to the unpredictable movements of the

[110] https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2a.html (Consultation Date January 2021).

[111] In the EU in 2020, there are some 126 nuclear reactors for electrical generation in 14 Member States and 5 more that are under construction. Nuclear generation reaches 25.2% of the energy generated in the EU as a whole. EURATOM SUPPLY AGENCY ADVISORY COMMITTEE: «Analysis of Nuclear Fuel Availability at EU Level from a Security of Supply Perspective». Report. March 2020.

demand, to another situation where it is the flexibility of the demand that also responds to the unpredictable movements of the supply, inherent to energy mixes with abundant renewable energy and an active demand[112]. The differences between generation structures, in grants and subsidies, in the payments for capacity or in the market design, will generate cost differences that will be transferred to the Union's entire production structure during the EGD's transition process[113].

Managing these differences without affecting the unity and cooperation required to position the EU at the head of the green transition process, is a challenge that will have to be responded by the Union´s institutions and the regulatory bodies of the different Member States, and particularly by the Government of each Member State. Seeking uniformity is no solution, but neither is smoothing over the disproportions. As Acemoglu stated when commenting on climate activism: «The markets do not have to stand in our way. Quite the contrary, they can be a powerful ally»[114]

Slowing up the transition: the OPEC strategies

The Organisation of the Petroleum Exporting Countries (OPEC) has been a part of the geopolitical world ever since it was founded in the 1970s, when as a consequence of the Yom Kippur War, the OPEC responded by cutting off the oil supply and causing the first oil crisis. From the very outset, the OPEC's and the oil market's trajectory have been a succession of ups and downs alternating from strategic cuts in production capacities, often for political reasons, and production increases to obtain stable prices that would facilitate world economic growth.

At present, it is undeniable that the way prices evolve on the hydrocarbon markets will condition the rate of the energy tran-

112 ROBINSON, David and MALCOLM KEAY: «Glimpses of the future electricity system? Demand flexibility and a proposal for a special auction». Oxford Energy Comment. The Oxford Institute for Energy Studies. October 2020.

113 For example, different regulations that affect the participation of electrical demands on the spot markets can lead to different incentives to promote electric vehicles in each Member State. OXFORD INSTITUTE FOR ENERGY STUDIES. «Electricity, Electric Vehicles, and Public Policy: Eight Key Takeaways». *Ibid.*

114 ACEMOGLU, Daron: «Are the Climate Kids Right?». Project Syndicate. 5t November 2019. https://www.project-syndicate.org/commentary/climate-change-economic-growth-by-daron-acemoglu-2019-11?barrier=accesspaylog (Consultation Date, January 2021).

sition towards a decarbonised world. High oil prices cheapen the cost of the transition making it economically more appealing to investors and consumers. The opposite occurs when prices are low. The OPEC has been defending a «balanced and stable» transition through a «gradual and orderly» process of change.

The OPEC undoubtedly and unambiguously supports the UN Framework Convention on Climate Change and the energy efficiency improvements, but: «the world must be aware that oil and gas are still essential and are going to be at the heart of the energy mix for the coming years. The impact of a ´perception crisis´ on long-term investments in the oil and gas industry, if it continues, could lead to supply shortfalls. This in turn would hurt national economies, threatening energy security and potentially creating social disruptions by making energy less affordable»[115]. So, the problem is finding the price level, not too high and not too low, that makes this difficult balance sustainable throughout the coming years.

For many years, the oil-exporting countries – -especially those in the Middle East – have been facing up to the challenge of diversifying their economies to find sources of revenue other than those obtained from oil exports. However, the results of these strategies are slow in coming and do not dispel the temptation to monetise the oil reserves as soon as possible if the green transition´s horizon approaches, or to withdraw part of the supply in order to obtain greater income through higher prices if that horizon recedes.

Managing to diversify their economies is no easy task for the oil exporting countries. The success with which such diversification can be achieved and the rate at which it can be implemented are shrouded in uncertainty. The exporting countries generally require far-reaching structural reforms and need to remove subsidies that are deeply rooted, and this will take time. The most likely outcome is that the countries whose economies depend on oil exports will adopt a hedging strategy to cope with the risks of transition by choosing conservative options aimed at retaining the competitiveness of their traditional energy sector and simultaneously increasing their resilience, through investments

[115] OPEC: «Oil industry ready and willing to tackle climate change issues». Bulletin Commentary October-November 2019. https://www.opec.org/opec_web/en/press_room/5772.htm (Consultation Date January 2021).

in decarbonisation, to face up to the potential risk of disruptions associated with the green transition[116].

Russia, now virtually a member of the OPEC, as it has recently demonstrated, is prepared to compete in oil and gas prices with the traditional producing countries and also specifically with the US. Its negotiating capacity is not at all inconsiderable because it is one of the biggest suppliers of these energy sources, mainly to Europe, but also to Asia[117]. Russia is prepared to compete in prices in its supplies to the EU and, together with the rest of the members of the OPEC, it is also in favour of a smooth transition rate.

The US, after the emergence of the new extraction technologies through fracking to obtain oil and gas, has almost become self-sufficient in hydrocarbons and is the biggest producer of crude oil in the world. The Trump Administration sought to reduce the cost of energy for US consumers by applying a foreign policy conducive to obtaining sufficiently low oil prices, instead of promoting higher prices in the world market and orienting its oil production to export. Unconventional oil is extracted at a variable cost around US$50 /bbl, which prevents –- even under the hypothesis that US companies were to flood the world markets – a significant disruption to the world prices that, nevertheless, are still sensitive to the production modifications made by the «swing producers» (Saudi Arabia especially with oil and Russia with natural gas)[118].

The EU is finding itself in a certain ambiguity where Russia is concerned: the (intended) competition policy defended by the Commission together with the Russian response, are leading to greater dependence on Russian gas (not so intended). Moreover, if the EU wishes to control and secure this dependence, it has to apply an *ad-hoc* regulation adapted to the reality of its relations

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116 FATTOUH, Bassam: «The Energy Transition & Adaptation Strategies for Oil Exporters», Oxford Institute for Energy Studies. OPEC Technical Workshop, 29 September 2020.

117 Gazprom is the gas supplier to the EU with the lowest marginal production costs, so Russia can hold on a low prices policy in competition with other sources and, especially, with the LNG coming from the US shale gas. Russia supplies 32.6% of the oil imports into Europe and 38.7% of the gas imports (in Germany this amounts to over 60%). It is also a fact that the European market guarantees over half of Russia's revenue from exporting gas, which balances this bargaining power.

118 LASHERAS, Miguel: «Give peace a chance: New opportunities in Saudi Arabia's geoeconomy». Energía y Geoestrategia. 2019. Instituto Español de Estudios Estratégicos. Comité Español del Consejo Mundial de la Energía. Club Español de la Energía. Ministerio de Defensa. 2019.

with Russia, taking particularly into account Germany's interests and position. For example, in line with the regulatory principles and standards in force in the EU[119], at no time have the officials of the Commission proposed capacity auctions in the way established by the current Network Code on Capacity Allocation Mechanisms in gas transmission networks. Had they done so, this would have required the Ukrainian regulators, when renegotiating the contract between Naftogaz and Gazprom that was ultimately signed in December 2019[120]; to organise an «open season», that is, the auction of annual capacity trenches for the next fifteen years, finding out the demand level to boost a domestic energy market and guarantee the gas supply from abroad.

Conflicts over the major energy corridors

Energy corridors are of vital importance for the green transition rate followed by the EU and for the way the EU handles the relationship with other countries, especially Russia, where the economic influence of the energy sector is very high: energy accounts for over 60% of its exports. Energy also amounts to 16% of the GDP and brings in 70% of the revenue in the federal budget[121]. To conserve this source of wealth and the geopolitical power that goes with it, it is essential to have transport routes or corridors that can convey the energy generated or extracted to its consumption points, currently and mainly in the EU.

Russian gas reaches Europe basically via three gas pipelines: Yamal, which crosses Belarus and Poland and first conveyed gas to Germany in 1997 before it was completed in 2005; Brotherhood, which is the oldest, entering the EU via Slovakia after running through Ukraine; and, since 2012, 'Nordstream 1' (NSI), which runs along the Baltic seabed[122]. Geopolitically, the NS is the

[119] REG (UE) 2017/459 issued by the Commission

[120] The Commission's position, according to Vice-President Sefcovic in April this year, was to consider that the main priority was to guarantee a long-term transit contract with a horizon of at least ten years.

[121] JIMENEZ BAEZ, Alberto: «El estado de la dependencia energética europea: La interdependencia rusa». Círculo de Análisis Euromediterráneo. Energía y Medioambiente. 23 November 2018. http://circuloeuromediterraneo.org/el-estado-de-la-dependencia-energetica-europea-la-interdependencia-rusa/ (Consultation Date January 2021).

[122] MARTIN PEREZ, Idafe: «Nord Stream II, la clave de las tensiones Moscú-Berlín». El Tiempo. 8 September 2020. https://www.eltiempo.com/mundo/europa/Germany-amenaza-por-primera-vez-a-Russia-con-interrumpir-nord-stream-2-536383 (Consultation Date January 2021).

gas pipeline that offers least dependence as regards its passage through third countries, so it is the route preferred by Russia and Germany, its original developers. NSI, with a capacity for 27,500 million cubic metres per year, could not originally compete with the other gas pipelines that cross Eastern Europe, so a decision was taken to double its capacity by constructing NSII. The two Nordstreams combined will be able to send 55,000 million cubic metres of gas every year from Russia to Germany, approximately half of Germany's annual consumption.

The construction of NSII has been interrupted as a result of penalties being imposed on the contracting and investing companies. The sanctions were decreed by the USA under *ad-hoc* legislation[123] and remained in force after the December 2019 Agreement between Gazprom (Russia) and Naftogaz (Ukraine) regarding gas transit. Despite these sanctions, NSII will be operational throughout 2021. As soon as it comes into operation, NSII will supply gas across the German-Czech border, to the Austrian hub in Baumgarten (Austria). From Baumgarten, the gas will reach Northern Italy, one of the major European destinations for gas exported by the Russian firm Gazprom, replacing the current flows that arrive via Ukraine, Slovakia and Austria itself.

The Eastern European countries such as Bulgaria, Poland, Hungary and Slovakia have all decidedly supported the policy of diversification at source of the imports, in order to alleviate the situation whereby they are dependent from Russia, whereas the major countries in Western Europe, Germany, France and Italy, have shown themselves to be in favour of strengthening their bilateral energy ties with Russia, and as a result, have given their backing to the construction of NS (I and II) and, albeit to a lesser extent, the construction of its «twin» via the south: the Turk Stream[124] which connects Russia to Turkey under the Black Sea. That is why in 2015 the EU withdrew its support from the Nabucco Gas Pipeline that links Austria with the Central Asia's

[123] This legislation consists of the National Defense Authorization Acts, the Countering America´s Adversaries through Sanctions Act and the Protecting Europe´s Energy Security Act. Based on the legal cover provided by these standards, the Department of State updates the dates, terms, conditions and quantities that give formality to these sanctions. The last one dates from 15th July 2020 with subsequent clarifications issued on 20th October. The EU understands that these sanctions are contrary to International Law, and thus, it does not recognise them.

[124] SEGOVIANO, Soledad: «España ante el reto de la seguridad energética». Working Document 56/2011. Fundación Alternativas. Observatorio de Política Exterior Española. 2011.

gas resources, also via Turkey, which would have operated as an alternative to the Turk Stream. Germany thinks that Russia is better tied to Europe than isolated, and so, regardless of the importance the EU institutions attach to energy diversification, it has played an active part in promoting these gas pipelines to transport gas coming from Russia.

In this process, Turkey has emerged as a new and major stakeholder. Both the Turk Stream and the TANAP gas pipeline – a Trans Adriatic gas pipeline involving ENAGAS (16%), BP (20%), the Azerbaijan firm SOCAR, the Italian firm Snam (20%), the Belgian firm Fluxys (19%) and the Swiss firm Axpo (5%) – which will transport Azerbaijan gas to Europe, grant Turkey, with respect to the EU, similar power to that which Ukraine has held in recent years. Turkey hopes to become a gas hub that channels to the EU, gas coming from Russia, Azerbaijan and even Iran[125].

However, certain contradictions become apparent in the natural gas horizon, as the EGD advances and is developed. On the one hand, a remunerative framework adapted to the new investments (NSII and the TANAP gas pipeline) is required as an alternative to the new transit agreement signed by Gazprom and Naftogaz[126]. Furthermore, between 2030 and 2050, natural gas should almost disappear as an energy source in the EU, theoretically giving way to hydrogen and renewable gases. Although in the immediate future, due to the implementation and development of the EGD, the EU will still need Russian gas, Russia began years ago consolidating its exports to China[127].

Furthermore, the EU's major gas and electric corridors are old, and largely obsolete, and are currently being extensively modernised. They are not sufficient to support the needs for a demand that is in keeping with climate neutrality and decarbonisation tar-

[125] SANCHEZ TAPÌA, Felipe: «Geopolítica en el Mediterráneo Oriental: algo más que gas». Energía y Geoestrategia 2020. Instituto Español de Estudios Estratégicos, Comité Español del Consejo Mundial de la Energía y Club Español de la Energía. Felipe Sánchez Tapia. Ministerio de Defensa, 2020.

[126] PIRANI, Simon and JACK SHARPLES et al. «Implications of the Russia-Ukraine gas transit deal for alternative pipeline routes and the Ukrainian and European markets». Energy Insights nº 65. The Oxford Institute for Energy Studies. March 2020.

[127] In 2014, Russia signed a $368,000 million contract with China to send 38,000 million cubic metres of gas per year to the latter, for 30 years, and, in December 2019 China received the first shipment of gas under this contract, via the Power of Siberia gas pipeline. See https://www.bbc.com/mundo/noticias-internacional-50647056 (Consultation Date January 2021).

gets and that competes with the major international energy corridors and the smart networks. An investment of approximately €140 billion in electricity and at least €70 billion in gas[128] will be required in the next few years to update the current networks and construct new ones.

Between 2014 and 2020, the EU used its Connecting Europe Facility (CEF) programme to invest €55.5 billion in large corridors, of which €7 billion were for the energy sector (less than 4% to Smart Grids) and most of it, €48 billion, was allocated to transport corridors[129]. It is not going to be easy to make the effort required by necessary investments in the next few years, and to a large extent, success will depend on these investments being suitably remunerated throughout their working life, which in turn depends on the regulatory system that each Member State had established. A recent European study that compared the different regulations concerning remunerations of gas and electricity grids concluded that, although investments associated with security of supply were sufficiently covered, those involving innovation and development were not. In particular, for example, those concerning «smart grids», because they reduce the need for physical investment and lower the financial return of the Transmission System Operators (TSOs) under the current remuneration framework[130].

In addition to the grids and gas pipelines, the maritime LNG distribution routes will also act as vital strategic corridors for supporting electrification by means of natural gas in the next few years. The Arctic is expected to become one of the main energy corridors between Asia and the West. The agreements for exploiting the Arctic have proved to be one of the best examples in recent years, of the effective combination by the power

128 https://ec.europa.eu/inea/en/connecting-europe-facility/ECf-Energy (Consultation Date January 2021).

129 EUROPEAN COMMISSION: «Investing in European networks. The Connecting Europe Facility. Five years supporting European infrastructures». Innovation and Networks Executive Agency. July 2019.

130 The EU has set as the target, interconnections for at least 10% for 2020, in order to encourage the Member States to connect their installed capacity. This goal for 2020 was a result of a call from the European Council in October 2014. At the same time, the Council also called the Commission to regularly inform about how to manage to increase this interconnection capacity to 15% by 2030. EUROPEAN COMMISSION: «Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure? Directorate-General for Energy. Directorate B – Internal Energy Market Unit B.1 – Networks & Regional Initiatives. March 2019.

blocks of strategies of political cooperation and strategies of conflict and sanctions. In 1996, the States with an Arctic frontier (Canada, Norway, Russia, the US, Denmark, Iceland, Sweden and Finland)[131] established a forum from which to tackle environmental protection and sustainable development in the Region.

Although the US Geological Service estimates that there are energy reserves of more than 400 billion barrels of oil equivalent, which amounts to 10% of the world´s crude oil reserves to be discovered and 25% of the gas reserves, the greatest interest in the Arctic at present revolves around the fact that the thawing which has recently taken place is turning the Northwest Passage and the Russian Northern Sea Route (NSR) into appealing accessible and transitable alternatives for commercial navigation. In some cases, these routes make the length of the journey 1.5 to 2 times shorter than the routes used until now.

In the first years of operation, the Arctic Council managed to achieve a certain balance between Russia and the US based on the limits imposed on hydrocarbon exploration in the Arctic, especially in the part belonging to Russia, to whom almost half the Arctic coastline and coastal zone belongs. This balance has also encouraged Russia to change its priorities, aiming them at opening up trade routes and, particularly, LNG corridors[132].

The interests of the EU have recently come into play. The European Union has never given up its aspiration to join the Arctic Council as an observer. In contrast to Russian interests, the EU has ambitious plans to develop a transport centre or hub in Kirkenes, which would be competing against the Russian ports on the Northern Sea Route (NSR). According to the Finnish project called the Arctic Corridor Project[133] the route would run from the north coast of Norway to the tunnel planned underneath the Gulf of Finland as far as to Estonia and then to Berlin. By connecting this Arctic route to a navigable waterway via the NSR, the EU hopes to make Kirkenes the main logistics hub for European

131 These States were joined by China, Japan, South Korea, India and Singapore as observers in 2003. KUERSTEN, Andreas: «The Battle for the Arctic». The National Interest. https://nationalinterest.org/print/feature/why-russia-should-not-be-feared-the-arctic-18192 (Consultation Date, January 2021).

132 KADOMTSEV, Andrei: «Battle for the Arctic: Friends and Foes». Modern Diplomacy. 17 August 2019. https://moderndiplomacy.eu/category/regions/russia-fsu/ (Reference Date, January 2021).

133 https://arcticcorridor.fi/ (Reference Date, January 2021).

goods coming from and going to China and would thus form part of the Polar Silk Road Project[134].

China views Russia's energy resources as a way of diversifying its sources, whereas the Europeans seek to associate themselves with the Asian nations to develop high-speed corridors for Internet and maritime seaways along the NSR[135]. Although the Arctic Council has functioned as a cooperation forum, growing tensions regarding control over critical minerals that are essential for the new technologies, the dispute over the new navigation routes and China's increasing involvement in the zone are piling pressure on the Region's governance framework. Once these tensions have been overcome, there are those who see the opening up of new transport routes in the Arctic as being an excellent opportunity for achieving seaways that internalise, from the beginning, the cost of the emissions that they release, restricting access to vessels that pollute and constructing infrastructures for using clean fuels in the ports that are constructed[136].

Not only the major European gas corridors, whether existing or new ones that might appear either via the LNG routes – especially in the Arctic – or because of the new gas pipelines that connect the EU with the exterior, but also the intracommunity energy transport structures that interconnect the Member States, will cause geopolitical tensions. In the former case to keep their operation stable and at peace, and in the second case to make the investments that are necessary to bring the green transition to fruition and guarantee security of supply, combining them with the development of a domestic energy market that operates under the principles of concurrence, non-discrimination and competition. Russia and the EU are condemned to understand each other and adjust their green transition rates to make recovering their investments in gas pipelines compatible with the decarbonisation of their economies. With a view to this, natural gas or

134 It must be remembered that, although committed to promoting sustainable projects, promoting ports, motorways, railways, dams, airports, trade & production in the One Belt One Road (OBOR) framework means higher emissions of CO_2, more pollution of the oceans and the atmosphere, more trees being chopped down, greater use of natural resources and burning of fossil fuels. HARRIS, JERRY: *Ibid*

135 FOREIGN POLICY: «Power Maps». https://foreignpolicy.com/2020/10/13/arctic-competition-resources-governance-critical-minerals-shipping-climate-change-power-map/?utm_source=PostUp&utm_m (Consultation Date, January 2021).

136 THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION: «VISION 2050: A strategy to decarbonise the global transport sector by mid-century». White Paper. Published on 21 September 2020.

green hydrogen will flow through the gas pipelines, but in either case it will basically come from Russia, so the hydrogen option cannot be solely European (or German).

Jurisdiction over taxation and the costs of CO_2

Tax harmonisation is one issue that will generate internal tensions and inconsistencies in the cost of production when compared the EU to other geopolitical areas of the world, mainly regarding the application of the green transition to taxes on energy and CO2 emissions. The current European framework for energy taxation, based on the 2003 Directive[137], has remained unchanged in recent years and is clearly obsolete. The Commission hopes to update it in Summer 2021, mainly in order to remove any fuel fossil subsidies that might still be lingering and to adapt the framework to the EGD. Subsidies and aid amounting to approximately €137 billions per year have persisted under this Directive, allocated to such sectors as aviation, maritime transport, land transport and the use of these types of fuels for electricity production. However, it will not be easy to find the required consensus. According to the TFEU, taxation decisions have to be unanimous if they are to be approved and modified. Poland and the Czech Republic have already stated that they are against the review of the Directive and Sweden does not appear to be in favour of abolishing the unanimity rule where taxation matters are concerned. The positions of Germany and France will be extremely important in this attempt to get the EGD to move forward in one of its vital aspects, i.e. energy taxation[138].

With regard to limiting emissions through taxation and the price of CO2, despite the deployment of renewables and the efforts made in the years before, no significant changes were observed in GHG emissions in 2019. As was announced in the COP 25 Summit held in Madrid at the end of 2019, carbon dioxide (CO2) emissions reached a record figure in that year, after three years of observing successive increases. Moreover, the relationship between economic growth and GHG emissions is difficult to decouple, even though the implementation of the emissions trading system in the EU (in 2005) and in other parts of the world.

[137] COUNCIL DIRECTIVE 2003/96/EC, dated 27 October 2003 restructuring the Community´s framework for the taxation of energy products and electricity.

[138] INVESTIGATE EUROPE: «The EU's broken Energy Taxation Directive: ripe for revision», 20 August 2020. https://www.investigate-europe.eu/en/2020/energy-taxation-directive-explained/ (Consultation Date January 2021).

Although CO_2 emissions decreased slightly in many industrialised countries, including the European Union, they increased in the world as a whole. Preliminary estimates indicate a drop of −1.7% for 2019, (−0.8%/year for the period 2003 to 2018) and for the US (also −1.7% in 2019, and also 0.8%/year for the period 2003 to 2018), together with a growth in India (+1.8% in 2019, +5.1%/year for 2003 to 2018), China (+2.6% in 2019, +0.4%/ year for 2003 to 2018), and the rest of the world ((+0.5% in 2019, +1.4%/year for 2003 to 2018)[139].

The main issuers of rights or titles that enable CO_2 to be released into the atmosphere are the EU and China. China is aiming to be the biggest market for emission rights, accounting for 3.3 billion tonnes per year. Yet the EU Emission Trading System (EU ETS) is still the biggest in the world and annually reaches 5% of the world emissions and 45% of the EU's (around 1.3 billion Tm/year). If the mechanism is to prove effective in reducing CO_2 emissions, every year the number of titles live or in circulation must decrease. As from 2021, the EU will apply a linear reduction of 2.2% every year, higher than the 1.7% applied in the previous years. This reduction factor is compatible with the emissions reduction target of 40% by 2030, compared with the emission levels in 2005. Although this goal falls within the margins set for the EU by the Paris Agreement, it does not reach the most ambitious reduction of up to 55% that was adopted in 2020. To attain the latter, the emissions limits associated with the living rights every year will have to be restricted even more for the 2021 to 2030 period.

The EGD proposes starting to put a price on CO_2 in such sectors as transport and building construction materials, making them converge with the general mechanism for trading emissions rights for 2030. Other aims of the Commission are to gradually phase out coal as an energy resource and ban any subsidies for hydrocarbons through the aforementioned updating of the 2003 Directive. But it is the promise of a Carbon Border Adjustment Mechanism (CBAM) that will have the greatest impact on the EU's relations with the rest of the world. The CBAM involves placing a carbon levy on the entry of goods on the basis of the CO_2 that has been emitted in each case, and doing so by applying rules that have to be compatible with the WTO.

[139] JACKSON, R. B. and P. FRIEDLINGSTEIN et al.: «Persistent fossil fuel growth threatens the Paris Agreement and planetary health.» Environmental Research Letters. 14.121001. 2019. https://iopscience.iop.org/article/10.1088/1748-9326/ab57b3 (Consultation Date January 2021).

According to the European lobby of carbon producers «Carbon Market Watch», the most suitable design for the CBAM is as an extension to the EU ETS for imports, in such a way that either the non-Community producers or the Community importers have to obtain the rights concerned on the basis of the carbon footprint associated with each one of the products imported (calculated by checking the processes utilised or by applying generally accepted standards)[140].

The collaboration of the countries or blocks that trade with the EU will be necessary when implementing the CBAM. A free-flowing dialogue will be needed that enables the CBAM to act as a cooperation mechanism between the parties and not one that leads to confrontation. Let us take into account that any CO2 border adjustment mechanism will inevitably be inconsistent with the non-discrimination clauses of the GATT because, by definition, it will mean distinguishing between products that are similar or comparable from a consumption or utilisation perspective, merely because one has a different carbon footprint from the other[141].

Moreover, the EU ETS could have asymmetrical effects within the Union if the different Member States draw up their policies supporting investment in renewables and decarbonisation without considering the «waterbed» effect, which occurs when support is given to investments to reduce emissions in sectors already covered by the EU ETS. When supporting an investment in renewable generation the rights to the emissions reduced by that investment must be cancelled. If this is not done the playing field will be unlevelled between economically similar sectors belonging to different Member States[142]. No technical problems are involved

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140 CARBON MARKET WATCH: «10 Key Principles for a Carbon Border Adjustment Measure (CBAM)», Positioning Paper, October 2020.

141 MARCU, ANDREI and MICHAEL MEHLING and AARON COSBEY: «Border Carbon Adjustments in the EU. Issues and Options». Roundtable on Climate Change and Sustainable Transition. 30 September 2020. https://ercst.org/border-carbon-adjustments-in-the-eu-issues-and-options/ (Consultation Date, January 2021).

142 GROSS, Daniel and MILAN ELKERBOUT: «Financing Europe's Green Deal: beware of the waterbed effect». CEPS. 4 March 2020. https://www.ceps.eu/financing-europes-green-deal-beware-of-the-waterbed-effect/ (Consultation Date, January 2021). For example, constructing or support the construction of a wind farm with public money may appear to be a green investment. Yet in a system like the UE ETS, all that is achieved is to help other energy generators to carry on emitting as before. This also applies to the subsidies for using coal in electrical generation, as is the case in Germany. Removing subsidies amounting to €50 thousand million only makes economic sense if the emission certificates for those coal plants are recovered and they are removed from the emissions market.

in controlling GHG emissions and removing subsidies from fossil fuels, and neither do either of them require new and sophisticated technologies. Even so, this is one of the aspects that receives most criticism for the progress of the EGD, and opposition is both internal, from the Member States with the highest emission levels, and external, from those who oppose border adjustments.

Asymmetries in traditional industries and new industries

One key sector for progressing with the green transition is the transport sector in all its different aspects. According to the International Energy Agency (IEA), this sector is responsible for 24% of the CO2 emissions on the planet, exactly 8.1 Gt, of which 44.4% are attributed to road passenger transport, 29.6% to road freight transport, 0.11% to air transport and the same percentage to sea transport, and 0.01% to rail transport[143]. The IEA understands it will be possible to completely decarbonise some of these transport subsectors in the coming decades through technologies that allow for greater electrification and the use of hydrogen: two-wheeled vehicles by 2040, trains by 2050, small lorries by 2060 and, even if the emissions from the rest of the wheeled transport (automobiles and buses) are not completely decarbonised until 2070, the IEA's scenario accepts that certain countries in the world, such as the United States, the EU, China and Japan, may ban the use of conventional engines by 2040[144].

The International Council on Clean Transport (ICCT) estimates that in the most optimistic decarbonisation scenarios, more than two thousand million vehicles driven by internal combustion will be sold over the next 30 years. The first conclusion to be drawn from this estimate is that it is essential that these vehicles are as efficient as possible in terms of emissions. The second conclusion is that it is difficult to demand a radical change in little more than one generation, in a sector that depends almost exclusively on one single energy source, oil, and that operates using infrastructures on which millions of millions of dollars have been invested for decades[145].

[143] https://www.iea.org/data-and-statistics/charts/transport-sector-co2-emissions-by-mode-in-the-sustainable-development-scenario-2000-2030 (Consultation Date January 2021).

[144] https://ourworldindata.org/co2-emissions-from-transport (Consultation Date January 2021).

[145] ICCT: «Vision 2050». *Ibid.*

Progress towards the use of electric vehicles (EVs) is unstoppable, but … at what rate? The decrease in the cost of the batteries used and support for favourable public policies have made the use of EVs the main change factor for transport in recent years. Use of EVs has risen spectacularly in urban environments, albeit unequally. In the third quarter of 2020, almost one out of every ten passenger vehicles sold in the EU was rechargeable (9.9%), whereas in the same period in the year before the percentage was only 3.0%[146]. During the first three months of 2020, the sale of EVs in the EU nearly doubled, rising from 250,079 between January and July 2019 to 570,278 for the same period in 2020. Even so, the sales of vehicles with traditional petrol and diesel engines remained steady at 75%. Approximately 97% of the world sales of EVs take place in four countries or regions (China, the US, the EU and Japan) and it is in some cities within these countries, such as Shanghai, Beijin and Los Angeles, where the highest proportion of sales occur[147].

It is essential to rally public support that can help and encourage the process of transformation towards EVs. The main promotion measures consist of financial incentives to make up for the difference in cost between EVs and conventional combustion vehicles; infrastructure deployment programmes; and information campaigns to put across to consumers the advantages and benefits of driving EVs[148]. These measures must be applied with a minimum of regional and social inequalities being caused and, when it is essential to do so, these must be assisted with compensation and mitigation programmes.

The percentage of people employed in the automobile industry in the manufacturing sector exceeds 20% in fourteen European regions. Five of those regions are in Germany. The rest are in Slovakia, Hungary, Italy, the Czech Republic, Romania and Sweden. There is no room for the internal combustion engine in a carbon neutral EU, so the entire European industrial model for vehicle production must adapt[149]. However, the adaptation rate

146 ACEA: «New passenger car registrations by fuel type in the European Union». Quarter 3. November 2020.

147 OXFORD INSTITUTE FOR ENERGY STUDIES. «Electricity, Electric Vehicles, and Public Policy: Eight Key Takeaways». *Ibid.*

148 WAPPELHORST, Sandra and DALE HALL et al.: «Analyzing policies to grow the electric vehicle market in European cities». White Paper. International Council on Clean Transportation. February 2020.

149 CAMERON, Aliénor and GRÉGORY CLAEYS et al. (BRUEGEL): «A Just Transition Fund: the best way to make the most of the European Union budget to enhance the necessary transition from fossil fuels to sustainable energy». *Ibid.*

will depend on what is happening both in the EU and in the rest of the world, where emerging markets, such as China, seek to lead the race for electric vehicles, associating them with broader industrialisation and energy security targets. In both Europe and the United States, most drivers and purchasers of EVs obtained these vehicles to replace their previous vehicles with traditional technology, in such a way that the EVs are being demanded as replacements (and as they are depreciated) for vehicles with traditional engines. By contrast, in countries with emerging markets like China and India, the purchasers are generally buying a car for the first time, so choosing vehicles that are 100% plug-in or mixed would make more sense to them[150].

Within the EU, there is no general consensus either between the Member States regarding the elimination of vehicles that are driven by traditional combustion. Although some of them, like Denmark, have individually incorporated their elimination targets into Laws, it is not clear how to enforce these targets in a way that results compatible with European regulations. Outside Europe, there are only two known experiences in the world, and both are local in nature, with binding and compulsory targets. One is in China (Hainan) and the other in Canada (British Columbia).

Yet apart from the characteristics of the demand and regulation, there are also structural differences in the sector that can cause asymmetries or a lack of uniformity between the different markets. For example, promoting EVs could be adversely affected by intermediaries or dealers who are not bundled with the manufacturers, since they may receive incentives to promote vehicles with traditional combustion engines before promoting electric vehicles (purchasing electric vehicles will involve consumers asking more questions and greater effort will be required to sell them, even though the cost of maintenance will be lower)[151].

The hydrogen sector is another emerging industrial sector that, like the automobile sector, is closely associated with the EGD, and it is a sector that has a strategy defined by the EU[152]. The EU's strategic target is to install at least 6 GW of renewable hydrogen

150 OXFORD INSTITUTE FOR ENERGY STUDIES. «Electricity, Electric Vehicles, and Public Policy: Eight Key Takeaways». *Ibid.*

151 This has been demonstrated in the market analyses conducted in the Nordic countries. OXFORD INSTITUTE FOR ENERGY STUDIES. «Electricity, Electric Vehicles, and Public Policy: Eight Key Takeaways». *Ibid.*

152 COM (2020) 301.

by electrolysis by 2024 and at least 40 GW by 2030. The hydrogen will mainly be applied to industry and mobility. By 2050, the cumulative investment in renewable hydrogen facilities will lie between €180 to 479 billion[153].

According to EU predictions, hydrogen will cater for 24% of the total energy demand by 2050, i.e., approximately 2,250 TWh/year. This energy would be the fuel used for 42 million grand touring cars, 1.7 million lorries, approximately a quarter of a million buses and more than 5,500 trains. It could heat over an equivalent of 52 million homes (about 465 TWh) and supply up to 10% of their electricity demand. In industry, roughly 160 TWh of hydrogen would produce high-power heat and a further 140 TWh would replace coal in steel mills. Hydrogen combined with captured carbon or carbon obtained from biomass could also provide the raw materials for 40 Mt of chemical products in 2050. It could also play a major role as a raw material for synthetic fuels (synthetic methane to be mixed with natural gas, ammonia potentially for sea transport and synthetic fuel for air transport)[154].

These targets can only be reached if a major transformation is made to the EU's industrial and economic fabric on the supply side, and to the uses and preferences of consumers on the demand side. As an energy source, it is estimated that hydrogen can create a fuel and associated equipment industry of around €130 billions for European companies by 2030, and that this would reach €820 billions by 2050. As a whole, the European hydrogen industry could create one million jobs for highly skilled workers by 2030 and would reach 5.4 million by 2050[155].

.However, these estimates could be very optimistic. Apart from the problems associated with the high cost of producing green hydrogen based on the technologies currently available, the outlook for this fuel faces two other problems. The first is that, as

153 The same communication from the Commission COM (2020) 301 gives information about the current cost of producing hydrogen using different technologies: 1.5 €/kg (38 €/MWh) for current production methods (without taking into account the cost of the CO_2). 2 €/kg (50 €/MWh) for «blue» hydrogen with carbon capture; and 2.5-5.5 €/kg (65–135 €/MWh) for «green» hydrogen obtained from renewable sources.

154 LAMBERT, Martin: «Hydrogen and decarbonisation of gas: false dawn or silver bullet?». Energy Insight nº 66. The Oxford Institute for Energy Studies. March 2020.

155 FUEL CELLS AND HYDROGEN JOINT UNDERTAKING: «Hydrogen Roadmap Europe: a sustainable pathway for the European energy transition». Prepared by McKinsey & Company. January 2019. Accessible at https://www.fch.europa.eu/ (Consultation Date, January 2021).

has already been pointed out, Russia will have to accompany the transition in the EU and replace the gas it sends with hydrogen[156]. Either the transitions in the two areas must keep in step with each other or the gas pipelines will merely be assets with sunk costs, unless natural gas continues to make incursions into the European markets without leaving any room for hydrogen and, in both cases, hinders progress with the transition in the EU. Furthermore, if gas and CO2 prices in the future are relatively low, around US $ 2 MMBTU and 25-30 €/Tn[157], it will be difficult the replacement of gas by fuels such as hydrogen and other renewable gases. The second problem is how a hydrogen economy subsidised and strongly supported by the public sector can live together the transnational, extensive, competitive and liquid market that the European Hydrogen Strategy for a climatically neutral Europe is opting for in the long term.

Nevertheless and according to the Commission: «…hydrogen plays an essential part in supporting the EU's commitment to achieving carbon neutrality by 2050 and in the global efforts to implement the Paris Agreements»[158].

Individual mobilisation to achieve efficiency in buildings and constructions

In December 2018, Directive EU 2018/2002 established a target for saving at least 32.5% through energy efficiency by 2030. The construction sector in the EU accounts for approximately 40% of its energy consumption, 36% of the total CO2 emissions and about half of the total emissions not covered by the EU ETS. Most of the energy currently used in buildings is lost due to construction practices that are now obsolete, the use of inefficient devices

[156] It is interesting to note that Germany is the first country in the EU to disclose a National Strategy for developing energy from hydrogen. The Federal Government opted for this strategy in 10 June 2020. On that very same day, the Russian Government published the Russian Federation's Energy Strategy, in which it stated that it was hoped Russia would be exporting 0.2 million tonnes of hydrogen per year by 2024 and 2 million by 2035. According to the Minister of Energy's Plans issued by the Minister of Energy, Russia hopes to capture 16% of the European hydrogen market. 2006 Russia and Hydrogen.

[157] FULWOOD, Mike: «$2 Gas in Europe: Groundhog Day?». Oxford Energy Comment. The Oxford Institute for Energy Studies. October 2020.

[158] EUROPEAN COMMISSION: Powering a climate-neutral economy: Commission sets out plans for the energy system of the future and clean hydrogen. Press Release. Brussels 8 July 2020.

and systems and a lack of effective control systems. From a technical viewpoint, this inefficiency can easily be overcome with thermal insulation, double glazing, preventing leakage and using efficient heat and cooling generation and distribution systems. Smart metering systems and distributed generation can also help to cause the demand to behave proactively in making the energy efficiency improvements that are needed.

The biggest problem that is expected for achieving these goals lies in the difficulties involved in mobilising the private financing required to pay for these investments in assets that will generate efficiency. It is estimated that approximately €275 billions will be needed yearly between now and 2030 to achieve the efficiency targets taken on for 2030. As individual projects are relatively small and the economic saving is obtained after relatively long periods of time, private investors and funders tend to overestimate the cost of the risk, what makes financing difficult. A feeling of uncertainty, potential regulatory risks and an unwillingness to join projects which will take a long time to reach fruition are all factors that can deter electricity consumers. If deficient information, complex decision processes and, at times, a relatively high outlay – -when compared to the energy saving throughout the useful life of the assets- are added to the aforementioned factors, they all constitute major barriers to motivating consumers and funders to take investment decisions that lead to energy efficiency. The solutions are not easy, but technical and legal standardisation at the different phases of the construction and investment processes would be of considerable help in mobilising the required resources, as several Community institutions have already pointed out[159]. The Commission has taken a series of initiatives to facilitate investments in efficiency and to overcome the barriers and difficulties that it has found in the wealth of experience it has gathered in promoting energy efficiency programmes:[160]

In conjunction with the EIB, the Commission is developing a flexible guarantee model to be implemented domestically as part of

[159] EUROPEAN COMMISSION: «Private financing of energy efficiency: new solutions for financing Europe’s energy transition». CORDIS. EU research findings. https://cordis.europa.eu/article/id/422225-private-finance-for-energy-efficiency-new-solutions-for-funding-europes-energy-transition/es (Consultation Date, January 2021).

[160] The first regulation goes back to 1974. Council Resolution 75/C 153/2 dated 17 December 1974 concerning energy policy targets for 1985. The most important milestone was the 2012 Energy Efficiency Directive (Directive 2012/27/EU).

the initiative Smart Finance for Small Buildings (SFSB). Its aim is to facilitate a combination of different lines of public financing (such as the funds from the European Fund for Strategic Investment and from the European Structural and Investment Fund) in order to obtain the best possible results.

Particularly useful in overcoming the difficulties involved in assessing the risks associated with these investments, are the shared databases and the tools to assess the risks. They have all been brought together as one single tool, namely the De-Risking Energy Efficiency Platform (Underwriting Tool), which was launched by the Commission in collaboration with the Energy Efficiency Financial Institutions Group (EEFIG). Moreover, experiences of this kind are worthwhile because they can be exported to other zones and applied in non-European environments.

According to the IEA[161], 10% of the funds contributed by the EU´s Recovery & Resilience Plan, which as has already been mentioned considers around €750 thousand million as NextgenerationUE funds to be spent in the next few years, will be earmarked for energy efficiency, This amounts to approximately €75,000 billions in direct grants and credits under advantageous terms to reinforce the rest of the measures aimed at achieving energy efficiency in the EU. This European effort accounts for 86% of the public encouragement announced in the world for recovery programmes associated with energy efficiency. The IEA's Sustainable Recovery Plan suggests for the rest of the world outside the EU, that they must also increase their energy efficiency-oriented recovery activities, because of their ability to create new employment (about 4 million extra jobs)[162].

EU's World Leadership

For the EGD to be the backbone of the EU's political strategy, there has to be de-escalation in the relations between the US and China. These new relations have to take the form of a new bipolarity very different from the type that existed during the Cold War in the 1950s and 60s. In the current situation, the Chi-

161 https://www.iea.org/data-and-statistics/charts/next-generation-eu-total-and-expected-climate-and-energy-related-spending-2021-2023 (Consultation Date, January 2021).

162 INTERNATIONAL ENERGY AGENCY: «Energy Efficiency, 2020». December 2020. https://www.iea.org/reports/energy-efficiency-2020/tracking-policy-responses-to-the-crisis (Consultation Date January 2021).

nese may be more concerned about defending themselves from US influence in Asia than about achieving and consolidating their world domination through confrontation. In the recent past, high growth rates have not caused Chinese society to take on the values inherent to the European welfare states, and that has created an uneven commercial and social arena. However, in the coming years, the Chinese «dual circularity» policy needs to raise the lowest salaries and improve social protection levels in order to achieve a sustained growth in domestic consumption and internal demand. This should help to attain more balanced trade relations with the West. If the US limits its responses and ignores certain calls to take preventive and military measures against the Chinese threats[163], the creation of a multipolar international order, with a balanced domination by China and the US, could assist the progress of the European EGD. These two countries are the only ones on the planet that are disputing the leadership of a fourth industrial revolution (5G, artificial intelligence, quantum Internet, etc.). If, as established in the EGD, the EU *can make the most of its strong points as world leader in taking measures on the climate and the environment, protecting consumers and workers' rights* it is essential for it to be able to count on the US and China to promote global projects and offer the public assets referred to in the EGD. In line with this, and as the EGD communication states, the EU must orient the common security and defence policy towards third countries, trying to ensure that the world challenges concerning climate and the environment do not serve as an «important magnifier» to increase tensions. It is essential «… to prevent these challenges from becoming sources of conflict, food insecurity, population displacement and forced migration, and support a just transition globally»[164]

In Section 3 of the EGD entitled, «The EU as world leader», its institutions are called to promote mobilising the countries in the world to adopt its policy of encouraging sustainable development. The European Council accepts that «international involvement is crucial for successfully tackling climate change. (…) and it appeals to the Commission and the High Representative to pay special attention to climate diplomacy.»[165] This EU's diplomacy as part of the Green Deal, together with trading policy, development aid

163 KAGAN, Robert *ibid*

164 COM (2019) 640 final. Page 25.

165 CROATIAN PRESIDENCY OF THE COUNCIL OF THE EUROPEAN UNION: «Subject: Long-term low greenhouse gas emission development strategy of the European Union

and other policies directed to the exterior, must also mobilise the G7, the G20, the WTO and other forums, the closest neighbours (e.g. Western Balkans), those in the South, the rest of Africa, Latin America, the Caribbean and Pacific Asia, and do so not only through bilateral channels but also through the United Nations' multilateral channels.

A basic aim that the EU's foreign policy must seek to achieve is to facilitate the export, with the due adaptations, of its experiences, especially with respect to governance and supranational tools, to third countries *«…*to establish international standards that are in harmony with the EU's environmental and climate ambitions»*.*

The international role of the EU, in a world dominated by bipolar tension between China and the USA will be to find a policy of its own («on my way»)[166] different from the sum total of the foreign policies of the different Member States and that manages to consolidate its leadership in encouraging the ecological transition without upsetting the balance between China and the US. China's sudden appearance, with its economic dynamism, its ideological distancing and its singular international expansionism, are making western climate diplomacy face an CPSL and uncertain future in a world where international cooperation and multilateralism will must overcome unilateralism and nationalism.

This need to promote from the EU international cooperation in the midst of this difficult geopolitical balance is described by Josep Borrell[167] in the following way: «As the EU, we have done and must do more to develop a level playing field in what human and social rights are concerned, by improving the so-called «due diligence» requirements demanded of the economic operators throughout their contracting chain. We must strengthen our trading policy to make sure the commitments taken on by our counterparts and trading partners with regard to social and environmental standards are adhered as a whole. We also have to reflect on the implications of a border carbon tax, without which the Green Deal would lead either to carbon leaks or to competi-

and its Member States». Submission by Croatia and the European Commission on behalf of the European Union and its Member States. Zagreb, 6 March 2020.

[166] BORRELL, Josep: «The Sinatra Doctrine». Política Exterior nº 197. 1 September 2020. https://www.politicaexterior.com/producto/la-doctrina-sinatra/ (Consultation Date, January 2021).

[167] Josep Borrell is the EU High Representative for Foreign Affairs and Security Policy and Vice-President of the European Commission for the period from 1December 2019 to 31 October 2024.

tive disadvantages. And of course, we must continue to lead the world in the struggle against tax havens.»[168] The truth is that the EGD as an EU commitment to the current world is an «all or nothing» wager that is credible because its very existence as a political entity is at stake.

Conclusions

With an international order in the process of transition towards a new equilibrium and determined to take action against climate change that needs new types of international cooperation and multilateralism, the European Institutions have directed their strategy for emerging from the crisis caused by COVID-19, towards investments that can lay the foundations for a modern and sustainable Europe that is leading the way. The backbone of this strategy is the EGD drawn up in December 2019 and perfected during the course of 2020. However, this ambitious strategy is not without its pitfalls. Probably the biggest of these is that from within the Union the support of the Member States breaks down and weakens it. That is why it is essential to set in motion the Just Transition System to make up for the economic and social imbalances caused by the green transition and in order to ensure that nobody is left out. If this internal unity is to remain intact, it is vital that the EGD adapts to the rate at which the foreign energy systems closest to the EU are progressing, especially the rates of Russia, Turkey and the «neighbours to the south», which are particularly sensitive to the period of time during which natural gas can be used and the potential that green hydrogen has for entering large-scale production. Security of Supply has to be compatible with the progress made by the domestic energy market; with the way it is designed and regulated; and with the *ad-hoc* contracts for guaranteeing supply from Russia. Electrification, the deployment of electric vehicles, the use of green gases such as hydrogen or the financing of the consumers' investments to improve efficiency and actively manage the demand, have to be compatible with not only supply but also demand being able to act with sufficient freedom to enable them to bear the cost and enjoy the benefits of their own decisions.

[168] BORRELL, Josep: «Building Global Europe», European External Action Service. From the Blog. 9 September 2020. https://eeas.europa.eu/headquarters/headquarters-homepage_en/84888/Building%20Global%20Europe (Consultation Date, January 2021).

The other major threat is that the EGD might not receive sufficient cooperation from other geopolitical power zones and especially from China, Russia and the United States. What international cooperation needs is for a new multilateralism to come into operation that can overcome the difficulties and problems with which the old international order was fraught. The traditional and inflexible respect for national sovereignty will have to be relaxed and broken down with the aid of the multilateral institutions. The potential strategic utilisation of REE monopolies must be lessened and its effects reduced. The principles of the GATT and the WTO have to be made compatible with CO2 border adjustments and fossil fuel subsidies must be curtailed. The international trade institutions have to make all these objectives attainable as soon as possible.

Joe Biden's triumph in the US will not eliminate the need for the new Administration to concentrate on its internal challenges. The US is returning to the Paris Agreement, but the EU cannot, and must not expect this return to put the two blocks in a similar situation to the 1970s and 1980s. Although a second triumph for Trump might have initiated an irreversible period of confrontation[169] probably with falls in world trade, new arms races and less effort in the policies aimed at encouraging the ecological transition, President Biden will be focusing most of his attention on the task of calming the country down and unifying it. The US's path in the green transition will be different from the European path and, in certain aspects they will even be competing against each other. Even so, the US is an essential ally for ensuring that the oil-producing countries do not slow down the rate at which the green transition is progressing. The strategic capacity that the US's oil and gas production offers using fracking techniques is, in the medium-term, necessary for preventing extreme strategies being used by the OPEC, especially Saudi Arabia and Russia.

One of the major paradoxes of China´s present time is the effort made by Xi Jinping to position himself as the champion of globalisation and decarbonisation, while at the same time imposing limits on the free movement of capital, information, goods and services[170]. The plans to relaunch the economy after the pan-

[169] More Hobbesian, according to HAASS, RICHARD: *Ibid.*

[170] In September 2021, in the UN General Assembly, the President of China, Xi Jinping, announced China's commitment to becoming CO2 neutral by 2060. This announcement amounted to a radical about-turn when compared to previous positions, which were much more radically in defence of coal as an energy fuel. ROWLATT, Justin: «Why

demic would appear to indicate that China is still not taking very seriously the efforts that the green transition requires, although facing the outward, it seems the opposite[171]. The time for this ambiguous behaviour could be coming to an end as long as the EU and the US are clear and firm in their progress towards energy transition. Whatever happens at the COP26 in Glasgow at the end of 2021, it seems vital to push a more committed Chinese position.

Furthermore, the EU must find its own way, which has to be sound and sustainable, preventing a global polarization as a result of the conflict between the USA and China, as well as Brexit[172], or the governments of the Member States, such as the autocracies in Hungary or Poland, do not weaken its unity from within. The EU has long-standing experience in making both the right and wrong decision in defining and developing energy-policy goals and measures applied while trying to maintain difficult balances between the sovereignty of the Member States and the Union's «supranational» institutions. This experience with mechanisms of governance that are compatible with national sovereignty; with statistical flexibility for financing green projects; with EU ETS schemes or with standardising sources of information and data, as well as experience with taxonomic or standardisation criteria for green projects, must all be valued for their «export» and consolidate their role in the geopolitics of the coming decades. With respect to the other power blocks, the EU has to act with a combination of unilaterality and cooperation, endeavouring to find the best solutions after analysing each particular case. Josep Borrell has defined this *modus operandi* in the following way: «We need to strengthen our capacities to act autonomously. The concept of 'Strategic Autonomy' is not about protectionism

2021 could be turning point for tackling climate change». BBC News. 1 January 2021. https://www.bbc.com/news/science-environment-55498657?utm_campaign=IEA%20newsletters&utm_source=SendGrid&utm_medium=Email (Consultation Date January 2021).

171 ANDREWS-SPEED, Philip et al.: «Does 2020 mark a critical juncture in China's low-carbon energy transition?». Energy Insight 76. The Oxford Institute for energy Studies. October 2020.

172 Although it is difficult to imagine a regulatory alignment between the EU and the UK after Brexit, the two are in perfect harmony in terms of environmental targets and ambitions. BRYDEN, DOUG and SARAH-JANE DENTON: «The European Green Deal –- A status report», Travers Smith. https://www.traverssmith.com/knowledge/knowledge-container/the-european-green-deal-overview-and-status-report/ (Consultation Date January 2021).

but about having the capacity to defend our interests and values by acting multilaterally whenever we can but being ready to act autonomously whenever we must.»[173]

Be that as it may, unilateral policies and uncooperative, authoritarian, autocratic and xenophobic polices may come to prevail over values that support the ecological transition. This threat is even greater after COVID-19. However, this is not new and much less inevitable. As was recently pointed out in Foreign Policy: *At the end of World War II, it was hardly preordained that Western Europe would be free, united, and prosperous. When the Cold War ended, a peaceful transition was anything but guaranteed*[174]*.* Today, the Green Deal may appear to be utopian, but from old Europe, especially since World War II, it will not be the first time that ceilings that seemed insurmountable have been broken.

[173] BORRELL, Josep: «Building Global Europe», From the Blog. European External Action Service. 25 November 2020. https://eeas.europa.eu/headquarters/headquarters-homepage_en/84888/Building%20Global%20Europe (Consultation Date January 2021).

[174] FUCHS, Michael H.: «A Foreign Policy for the Post- Pandemic World How to Prepare for the Next Crisis», Foreign Affairs. 23 July 2020. https://www.foreignaffairs.com/print/node/1126222 (Consultation Date January 2021).

Chapter three

Clean Hydrogen: Building Block of a New Geopolitical Landscape

Thijs Van de Graaf

Abstract

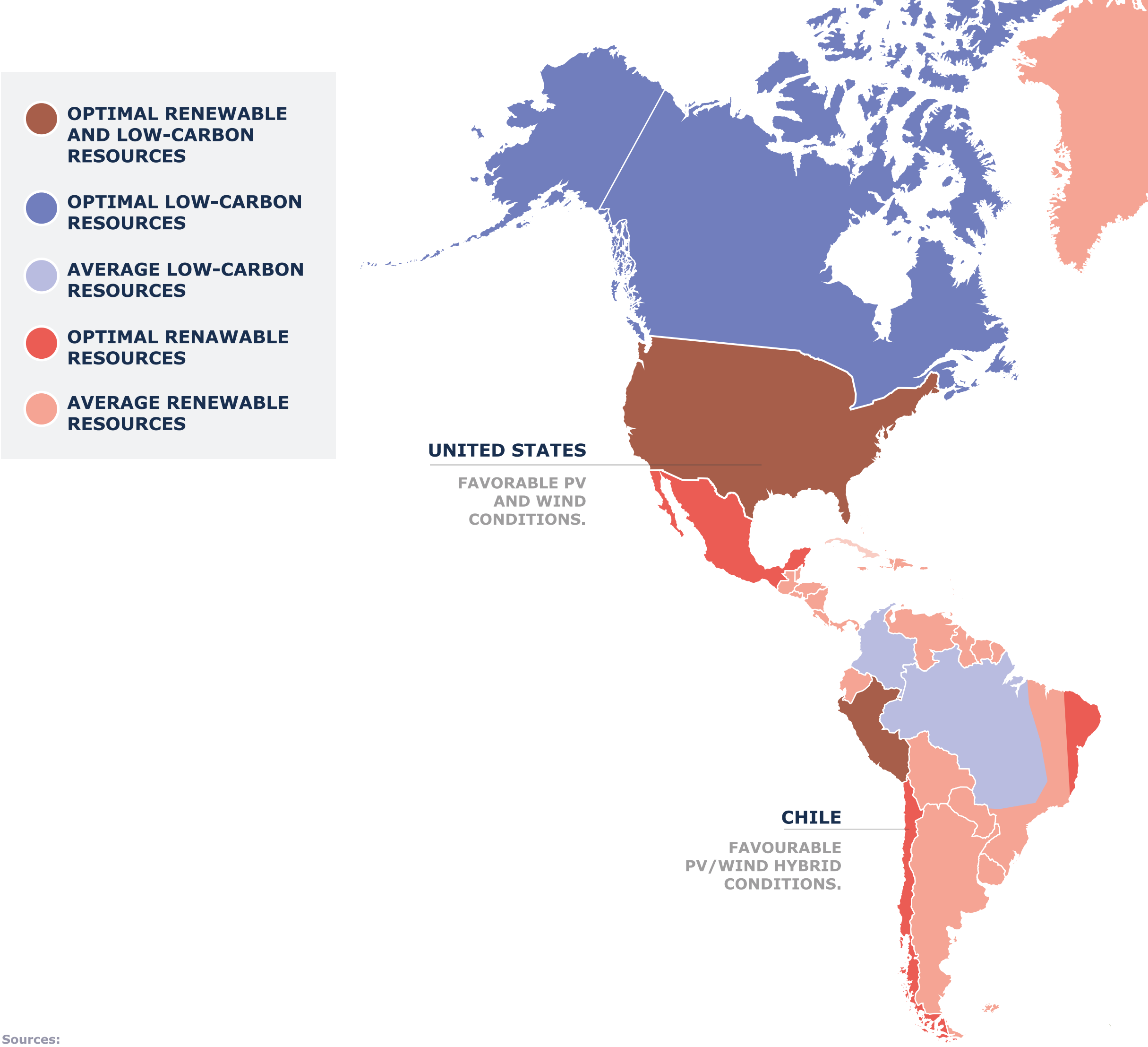
Hydrogen and derived gases (such as ammonia and methanol) are currently enjoying renewed political and business momentum, based on the declining cost of renewable electricity and surging interest in deep decarbonization, as more and more countries rally behind net zero emission targets by mid-century. This chapter presents an overview of the geopolitical dimensions of hydrogen as a clean energy carrier. To that end, it first reviews the technical characteristics, different production methods and areas of application of hydrogen. Next, the chapter examines whether and how hydrogen and derived fuels could become globally traded energy commodities, and which countries are poised to become the hydrogen superpowers of the future. Finally, this chapter identifies six areas where hydrogen might shape geopolitics in the coming years: technology dominance, geo-economic competition, the future of petrostates, new interdependencies, carbon lock-in, and global governance. The chapter finds that hydrogen has the potential to become a global commodity, although the size and scope of that market is still very contested and uncertain. While the geopolitical stakes in this emerging business are high, hydrogen will not become a zero-carbon version of oil, contrary to popular belief. If anything, it will bear more resemblance to the liquefied natural gas (LNG) market.

Keywords

Geopolitics; Hydrogen; Synthetic Fuels; Energy Transition; Trade.

HYDROGEN PRODUCTION POTENTIAL ACROSS REGIONS

BEST SOURCE OF LOW-CARBON HYDROGEN IN DIFFERENT REGIONS

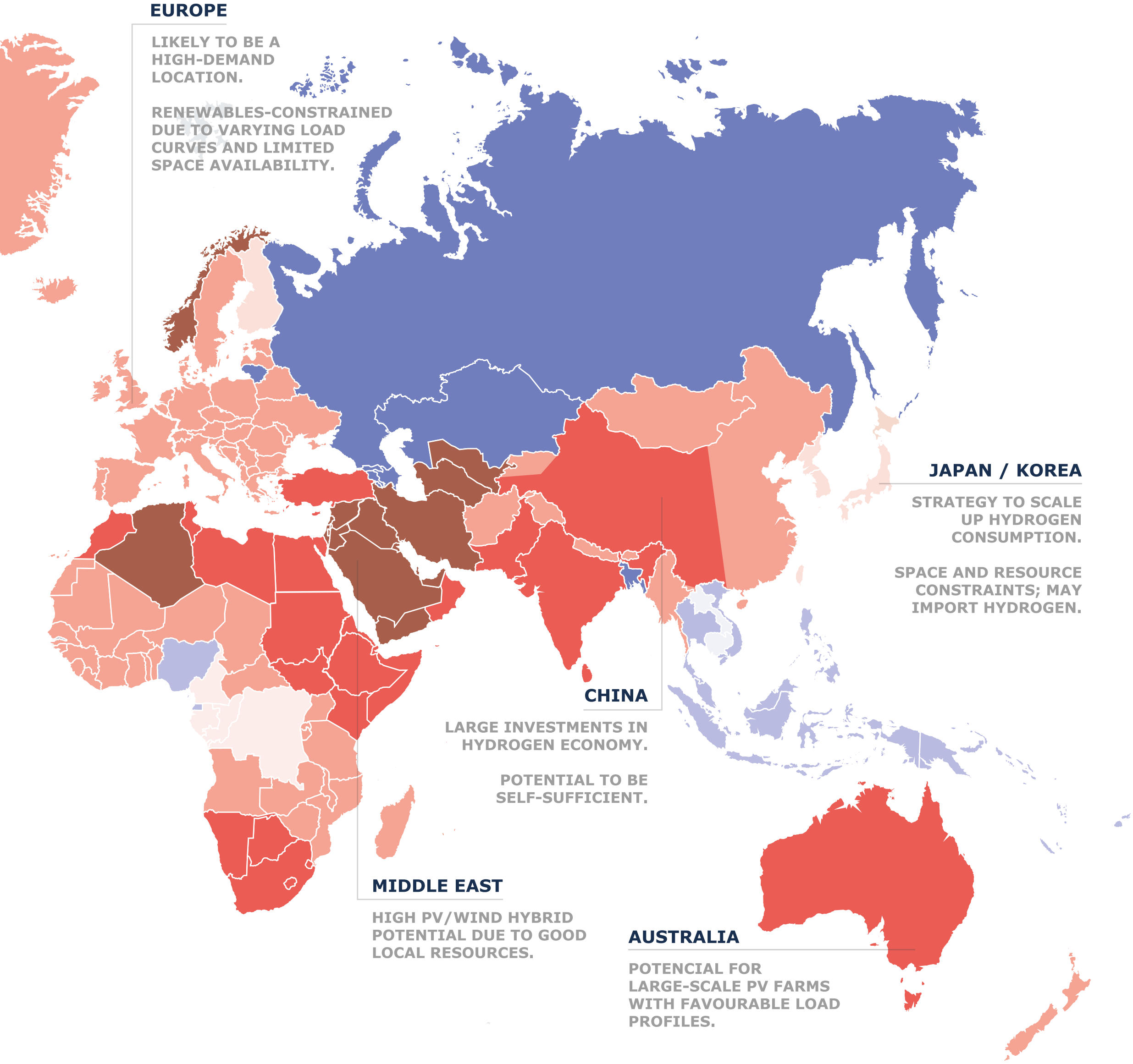


Sources:
Map: Hydrogen Council - Path to Hydrogen Competitiveness, 2020 - Page 22.
Table 'Selection of Low-Carbon Hydrogen Types': IRENA - Green Hydrogen Policy, 2020 - Page 8.

DEMAND CENTRES, E.G. EU, NORTH-EAST ASIA, ARE OFTEN CONSTRAINED FOR RESOURCES, AND MAY NOT BE ABLE TO SELF-SUPPLY HYDROGEN.

COUNTRIES WITH COMPLEMENTARY LOAD PROFILES OF WIND AND PV CAN PRODUCE RENEWABLE HYDROGEN AT VERY LOW PRICES.

REGIONS LIKE CHINA AND THE US ARE BOTH DEMAND CENTRES AND HAVE FAVOURABLE RES.



SELECTED SHADES OF HYDROGEN

COLOR	GREY HYDROGEN	BLUE HYDROGEN	TURQUOISE HYDROGEN	GREEN HYDROGEN
PROCESS	SMR OR GASIFICATION	SMR OR GASIFICATION WITH CARBON CAPTURE (85-95%)	PYROLYSIS	ELECTROLYSIS
SOURCE	NATURAL GAS OR COAL	NATURAL GAS OR COAL	NATURAL GAS	RENEWABLE ELECTRICITY

Note:

SMR= *Steam Methane Reforming*

Turquoise hydrogen is an emerging decarbonisation option.

Introduction

For decades, international relations (IR) pundits used the word «hydrogen» only in relation to the hydrogen bomb, a weapon of mass destruction that is many times more powerful than the conventional atomic weapons that destroyed Hiroshima and Nagasaki. Today, a more peaceful application of hydrogen has entered the lexicon of IR specialists: that of hydrogen as an energy carrier and a feedstock. Since 2017, hydrogen gas and its many derivative forms (e.g., hydrogen-based methanol or ammonia) are back in vogue as critical solutions for moving our economies towards net zero emissions by the middle of the century.

This is not the first wave of interest in hydrogen as an energy carrier. Hydrogen gases sparked a first wave of enthusiasm in the wake of the petroleum shortages experienced by the West in the 1970s. Hydrogen produced from coal and nuclear was touted as a means of replacing vulnerable oil imports, especially as a transportation fuel. Enthusiasm for hydrogen waned as oil prices declined, but a new wave of interest arose in the 1990s, this time spurred on by concern about climate change. Yet, persistent low oil prices stifled many hydrogen projects. By the early 2000s, the hydrogen hype returned, amid widespread fears over peak oil. After 2010, as oil scarcity fears subsided, hydrogen again faded into the background[1].

Today, two evolutions have dramatically shifted the outlook for hydrogen. First, the dramatic cost reductions for renewable energy technologies such as solar and wind have improved the prospect of «green hydrogen» (produced from electrolysis of water powered with renewables) one day becoming competitive with fossil fuels – by as soon as 2030 according to the International Renewable Energy Agency (IRENA)[2]. For most places in the world, renewables are now the cheapest source of electricity[3].

[1] International Energy Agency (IEA), «The Future of Hydrogen», Paris: OECD/IEA. Available at: https://www.iea.org/reports/the-future-of-hydrogen. Accessed: 11 January 2021.
[2] International Renewable Energy Agency (IRENA), «Green Hydrogen Cost Reduction: Scaling Up Renewables to Meet the 1.5°C Climate Goal», Abu Dhabi: IRENA, 17 December 2020. Available at: https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Dec/IRENA_Green_hydrogen_cost_2020.pdf. Accessed: 13 January 2021.
[3] International Renewable Energy Agency (IRENA), «Renewable power generation costs in 2019», IRENA, June 2020. Available at: https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019. Accessed: 11 January 2021.

The IEA now refers to solar photovoltaics (PV) as «the cheapest source of electricity in history»[4]. Just like solar and wind, electrolysers are on technology learning curves, and can experience similar cost reductions like those we have seen for renewable technologies. Green hydrogen is technically a subcategory of renewable electricity, from which it is produced. As such, hydrogen might enable the penetration of cheap renewable electricity sources into other end-use sectors like industry, transport and buildings where it might displace fossil fuels.

Second, governments have adopted the Paris Agreement in late 2015, which states the aim of limiting global warming to well below 2° Celsius and pursuing efforts to keep it under 1.5°C. Even though the initial nationally determined contributions (NDCs) fell well short of that temperature goal, governments seem increasingly serious about climate mitigation. If the incoming Biden administration follows through on its promise, soon more than two-thirds of global CO2 emissions will be under a net zero commitment by the middle of the century[5]. To achieve this goal, zero-carbon hydrogen could be an important or even indispensable technical solution to decarbonise sectors which are hard to electrify, such as shipping, aviation, long-haul transport, and high-heat industrial processes[6].

Thanks to these evolutions, this time may be different, and the hydrogen industry may finally take off after several false starts. Hydrogen may even give way to large, new international trade flows. Big, industrialised countries like Japan, Korea, Germany and the rest of the European Union (EU) are betting on large-scale imports of hydrogen to meet their net zero commitments. Hydrogen could thus give way to a large and potentially lucrative new commodity market, and this is attracting the attention of governments and the boards of large corporations. If hydrogen is set to become an important energy carrier in the future, a zero-carbon version of oil, the industry is surely one of high risks and immense geopolitical stakes.

[4] International Energy Agency (IEA), «World Energy Outlook 2020», Paris: OECD/IEA, p. 214.

[5] United Nations Environment Program (UNEP), «Emissions Gap Report 2020», p. xvii. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/EGR20.pdf. Accessed: 13 January 2021.

[6] Ronnie Belmans and Pieter Vingerhoets, «Molecules: Indispensable in the Decarbonized Energy Chain», EUI RSCAS PP, 2020/01, Florence School of Regulation. Available at: http://hdl.handle.net/1814/66205. Accessed: 18 January 2021.

What makes hydrogen so appealing to policymakers is that it can provide a secure and reliable supply of energy and heat at all times, night or day, winter or summer, at a cost that is bound to come down and without emitting carbon dioxide (if produced from renewables or nuclear)[7]. It is a key enabler of sector coupling, as well as a storable and dispatchable energy carrier (in contrast to intermittent sources of electricity from solar and wind). Since it can be stored in unlimited quantities, hydrogen is *the only* solution that can provide deep resilience to the highly electrified net-zero economy of the future[8]. Unlike oil and gas, it can be produced anywhere in the world, reducing the risks of asymmetric trade relationships that can be politically exploited by either side.

This chapter seeks to expose the geopolitical dimensions of hydrogen. To that end, it proceeds in five parts. The next section reviews the technical potential and economic cost of different hydrogen value chains, covering both hydrogen's production methods and its potential use cases. The subsequent section attempts to identify the key players in the global hydrogen game, combining a general overview with case studies of Japan, the European Union, Australia and Chile. Next, we move on to discuss the geopolitical drivers and implications of current hydrogen developments. Six geopolitical dimensions of hydrogen are identified and discussed at length:

- The race to attain technological leadership;
- Trade frictions and competitive industrial strategies;
- Impact of hydrogen on the future of petrostates;
- New interdependencies arising from international hydrogen trade;
- Risks of carbon lock-in and stranded assets;
- Competitive regulation and governance of hydrogen markets.

What is hydrogen?

Technical characteristics

To fully apprehend the revolution that hydrogen may unlock, it is important to understand a few basic scientific principles regarding

[7] Thierry Lepercq, *Hydrogen is the New Oil: How 7 Energy Battles are Giving Birth to a Carbon-Free World*. Paris: Cherche Midi, 2019.

[8] Michael Liebreich, «Separating Hype from Hydrogen – Part Two: The Demand Side», 16 October 2020. Available at: https://about.bnef.com/blog/liebreich-separating-hype-from-hydrogen-part-two-the-demand-side/. Accessed: 22 December 2020.

hydrogen. Hydrogen is the lightest and most abundant element in the universe. It is a diatomic gas designated with the molecular formula H_2. It is nontoxic, non-metallic, odourless, tasteless, carbon-free, and highly combustible. Hydrogen rarely occurs as a free molecule in nature, but tends to be associated with other elements, notably oxygen (to from water, or H_2O) and carbon (to form various forms of hydrocarbons, including fossil fuels, such as methane or CH_4).

Today, hydrogen is almost exclusively used as a feedstock for other chemical products, including ammonia (NH_3), a critical input product to make nitrogen fertilizers, methanol (CH_3OH), ethanol (C_2H_5OH). At oil refineries, it is also added to heavier oil to produce transport fuels. At present, the production of ammonia and oil refining accounts for two-thirds of global hydrogen use[9]. Industrial demand for hydrogen is already a very important global market, with a total demand of around 115 metric million tons in 2018[10], worth 135.5 billion dollars,[11] and is experiencing rapid growth.

Yet, hydrogen also has a lot of potential as a *chemical energy carrier*, or an *energy vector*. It contains more energy per unit of weight than fossil fuels. As a fuel, hydrogen can be reconverted into electricity or heat through the following chemical reaction: $2H_2 + O_2 \rightarrow 2H_2O$ + electricity + heat. This can be achieved through actual combustion (just like natural gas or coal in power plants or oil in vehicle engines) or through oxidation in fuel cells. In both cases, hydrogen does not produce any carbon dioxide (CO_2), particulate matter (PM), sulphur oxides (SO_x), nitrogen oxides (NO_x), nor does it raise ground-level ozone (O_3). Its only side-product is water vapor (H_2O), which is completely innocuous. The benefits of hydrogen for mitigating climate change and local air pollution are thus widely cited.

It is very important, however, to underline that hydrogen is not an energy source. It cannot be extracted from the ground or the atmosphere like crude oil or solar irradiation. Instead, it is an energy carrier or energy vector, just like electricity. This means that it needs to be produced, using other energy sources. Currently,

9 International Energy Agency (IEA), «The Future of Hydrogen», Paris: OECD/IEA. Available at: https://www.iea.org/reports/the-future-of-hydrogen. Accessed: 11 January 2021.

10 IEA, «The Future of Hydrogen», p. 18.

11 Baker McKenzie, «Shaping Tomorrow's Global Hydrogen Market Via De-Risked Investments», January 2020. Available at: https://www.bakermckenzie.com/-/media/files/insight/publications/2020/01/hydrogen_report.pdf?la=en. Accessed: 11 January 2021.

more than 99% of all dedicated hydrogen production is from fossil fuels[12], thus leaving a substantial CO2 footprint. In fact, hydrogen production is currently responsible for annual emissions equivalent to those of the United Kingdom (UK) and Indonesia combined[13]. With current production methods, hydrogen has no role to play in global decarbonization efforts. However, there are other production methods, which will be reviewed in the next subsection.

Production methods

The various ways of producing hydrogen are typically described by using different colour codes (see Table 1). «Grey» is used to refer to the production of hydrogen from fossil fuels. It is sometimes also be referred to as «brown» hydrogen (if it's based on brown coal or lignite) or «black» hydrogen (if it's based on black coal). By far the biggest chunk of hydrogen (around 75%) is produced through steam methane reforming (SMR), which brings together natural gas and heated water in the form of steam. The output is hydrogen and carbon dioxide. Coal gasification comes next, accounting for an additional 23% of hydrogen production[14]. Given the large CO2 emissions implied by these production methods, they are unsuitable for reaching net zero emission targets.

Colour	***Process***	***Source***	***CO_2 emissions***
Grey hydrogen	Steam methane reforming (SMR) or gasification	Natural gas or coal	High
Blue hydrogen	SMR or gasification with CCS	Natural gas or coal	Low
Turquoise hydrogen	Pyrolysis	Natural gas	Close to zero if heat is provided by renewables or nuclear
Green hydrogen	Electrolysis	Renewable electricity	Close to zero
Pink hydrogen	Electrolysis	Nuclear electricity	Close to zero

Table 1. The main shades of hydrogen

12 IEA, Future of Hydrogen, p. 32.
13 IEA, «Future of Hydrogen», p. 14.
14 IEA, «Future of Hydrogen», p. 38.

In theory, both production processes could be equipped or retrofitted with carbon capture and storage (CCS) technology, in which case it is referred to as «blue» hydrogen. CCS technologies allow only to capture 85-95% of CO2 emissions at best[15], making blue hydrogen far less carbon intensive than its grey or black counterparts, but still not carbon neutral. In addition, continued reliance on natural gas extraction implies a risk of upstream leakages of methane, a far more potent greenhouse gas than CO2. Moreover, such retrofitting involves additional costs for capturing, transporting and storing CO2, and may face social acceptance issues[16]. In energy security terms, blue hydrogen still relies on a finite resource base, is exposed to fossil fuel price fluctuations, and may involve a continued reliance on imports from unstable supplier countries.

Another production route is called «turquoise» hydrogen. It uses natural gas as a feedstock but does not produce any CO2 emissions. Through the process of pyrolysis, the methane or natural gas (CH4) breaks down in gaseous hydrogen (H2) and solid carbon (C). Interestingly, a market for solid carbon already exists, which gives opportunities to tap into an additional revenue stream. The same can be said about CO2 in schemes that provide for the utilization of captured carbon dioxide, but solid carbon can be more easily stored than gaseous CO2. To make this production technique carbon neutral, the high-temperature heat must be generated through renewables or nuclear and the carbon residue must be permanently bound. At the moment, turquoise hydrogen is still at the pilot stage.

«Green» hydrogen is made through water electrolysis based on renewable-generated electricity. Electrolysis was invented by two British chemists back in 1800. It is a process that uses electrical current to split water into hydrogen and oxygen. Electrolysers consist of two electrodes (anode and cathode) separated by an electrolyte. There are different types of electrolysers mainly based on the type of electrolyte material involved. The full life-cycle greenhouse gas emissions of hydrogen production via electrolysis are close to zero if the electricity is produced from renewables such as solar and wind. However, in most cases, grid-

[15] International Renewable Energy Agency (IRENA), «Green Hydrogen Cost Reduction: Scaling Up Renewables to Meet the 1.5°C Climate Goal», Abu Dhabi: IRENA, 17 December 2020, p. 16.

[16] International Renewable Energy Agency (IRENA), «Green Hydrogen: A Guide To Policy-Making», Abu Dhabi: IRENA, November 2020, p. 9.

based electricity comes from a mixture of sources. This is why the European Commission, in its Hydrogen Strategy, makes a distinction between «electricity-based hydrogen» and «renewable hydrogen»[17]. Renewable hydrogen may also be produced through the reforming of biogas or biochemical conversion of biomass.

Another colour in the spectrum of hydrogen technologies is «pink», referring to hydrogen made from nuclear electricity, also through electrolysis. Pink hydrogen is rarely mentioned in European hydrogen strategies, but it might become an important mainstay of hydrogen industries in countries like Russia and China[18]. After this, the colours get a little bit blurry. «Yellow» hydrogen is used by some to describe electrolytical hydrogen using a mix of renewable and fossil power. «White» hydrogen, finally, is naturally occurring geological hydrogen found in underground deposits and created through fracking, although there are currently no viable exploitation strategies.

Areas of application

One of the most appealing aspects of hydrogen is its versatility. It can be fed into the gas network, used in fuel cell vehicles, converted to other synthetic fuels, or converted into electricity for the grid. By enabling the conversion of electricity into molecules (through electrolysis), and back again (through fuel cells), it is a key enabler of «sector coupling», one of the buzzwords in energy circles which refers to the integration of different energy-consuming sectors (e.g., buildings, transport, and industry) with the electricity sector. Hydrogen allows renewable electricity to be converted to gas molecules (a process referred to as «power-to-gas») which in turn allows to decarbonize parts of industry and transport, which cannot be electrified.

There are also important synergies between hydrogen and a renewable-powered electricity system. Hydrogen broadens the reach of renewable solutions, for example in industry. It is also virtually the only way provide seasonal and carbon-neutral stor-

[17] European Commission, «A hydrogen strategy for a climate-neutral Europe», Brussels, 8 July 2020, pp. 3-4.

[18] Noussan, Michel, Pier Paolo Raimondi, Rossana Scita, and Manfred Hafner. «The Role of Green and Blue Hydrogen in the Energy Transition – *A Technological and Geopolitical Perspective*», *Sustainability* 13, no. 1 (2021): 298.

age of renewable electricity[19], and thus has an edge over batteries, which can provide storage for a few hours at most. Some have suggested that hydrogen could also potentially provide a means to deal with the issues of curtailment of variable renewable generation and negative electricity prices, but research has found that building electrolysers to store curtailed power may not always make sense[20]. On the other hand, electrolysers could add an element of demand side flexibility («peak shaving») to balance the grid at all times[21]. Finally, hydrogen allows to ship renewable energy over much longer distances than high-voltage direct current cables are able to do. This aspect is called «shipping the sunshine» in Germany's national hydrogen strategy[22].

Some proponents have an expansive view of the role of hydrogen in society, and advocate its use across all sectors of the economy. Japan's national hydrogen strategy has the explicit aim of turning the country into the world's first hydrogen society[23]. Yet, one of the disadvantages of hydrogen is that with each conversion comes an energy loss. The laws of thermodynamics dictate that the energy content which comes out of the hydrogen production process is always less than the electricity or natural gas that went in. Roughly, this translates into the following, simple arithmetic: the conversion of electricity, green or not, into hydrogen implies a loss of about 30% of the energy content of electricity. Whatever subsequent step is taken to put the hydrogen into practical use (e.g., fuel cells or hydrogen combustion) will involve another 30% loss (of the 70% energy remaining in the hydrogen), alto-

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19 DNV GL, «The Promise of Seasonal Storage», Position Paper, February 2020. Available at: https://www.dnvgl.com/publications/the-promise-of-seasonal-storage-168761. Accessed: 18 January 2021.

20 UK National Infrastructure Commission (NIC), «Net Zero: Opportunities for the Power Sector», 6 March 2020. Available at: https://nic.org.uk/app/uploads//Net-Zero-6-March-2020.pdf. Accessed: December 22, 2020.

21 International Renewable Energy Agency (IRENA), «Hydrogen: A Renewable Energy Perspective», Report prepared for the 2nd Hydrogen Energy Ministerial Meeting in Tokyo, Japan, September 2019. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf. Accessed: 11 January 2021.

22 The German Federal Government, «The National Hydrogen Strategy», Federal Ministry for Economic Affairs and Energy, June 2020. Available at: https://www.bmbf.de/files/bmwi_Nationale%20Wasserstoffstrategie_Eng_s01.pdf. Accessed: 11 January 2021.

23 Japanese Ministry of Economy, Trade and Industry, «Basic Hydrogen Strategy», December 26, 2017. Available at: https://www.meti.go.jp/english/press/2017/pdf/1226_003b.pdf. Accessed: 11 January 2021.

gether leaving about half the energy in the original electricity being available for useful purposes[24].

If one compares different passenger vehicle drive technologies, as shown in Figure 1, battery-electric vehicles (BEV) have the highest efficiency rating (69%). Hydrogen fuel cell electric vehicles (FCEV), by contrast, have conversion losses that amount to 74% and this even increases to a staggering 87% for cars that burn hydrogen-derived synthetic fuels. This means that it requires approximately 2.5 times as much electricity to drive the same 100 km with a FCEV as it would with a BEV, and about five times as much electricity to run the same vehicle with synthetic fuels. The reason is very simple. Cars with fuel cells are basically electric vehicles, but there are two extra conversion steps compared to battery powered EVs: energy must move from wire to gas to wire in order to power a car. A similar story applies when comparing electric heat pumps with hydrogen boilers or fuel cell heating systems (Figure 2).

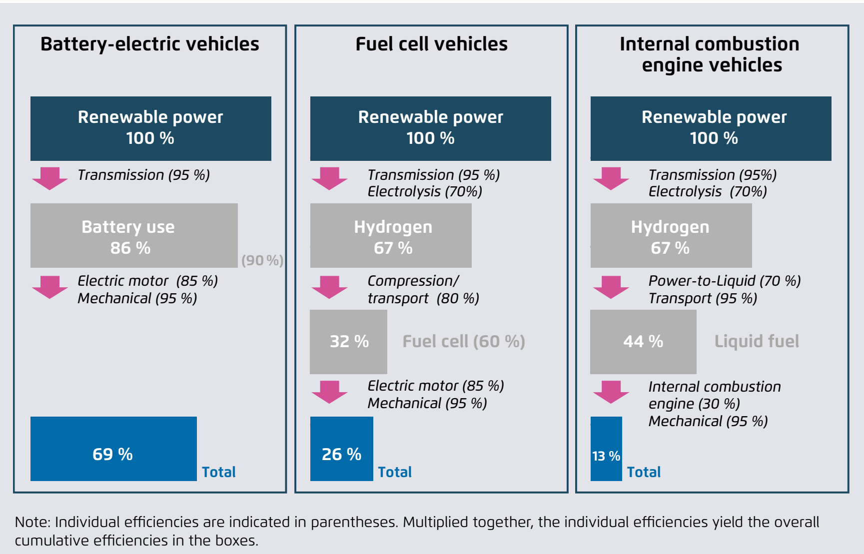
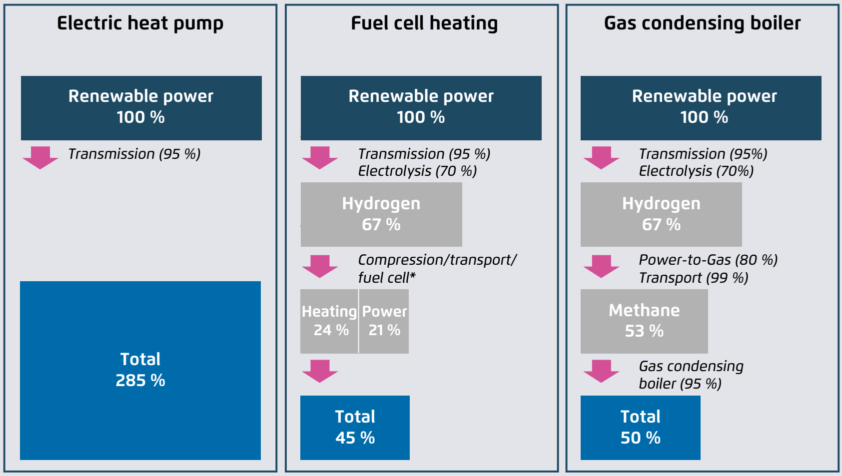


Figure 1. Conversion efficiencies for cars with different drive technologies[25].

[24] Jorgen Henningsen, «Why hydrogen is no magic solution for EU green deal», *EU Observer*¸ 4 August 2020. Available at: https://euobserver.com/opinion/149089. Accessed: 11 January 2021.

[25] Agora Energiewende and Frontier Economics, «The Future Cost of Electricity-Based Synthetic Fuels», 19 September 2018, p. 12. Available at: https://static.agora-energiewende.de/fileadmin2/Projekte/2017/SynKost_2050/Agora_SynKost_Study_EN_WEB.pdf. Accessed: 11 January 2021.



* Efficiencies: 80% (compression/transport) and 85% (total fuel cells; 45% heating, 40% power)

Note: Individual efficiencies are indicated in parentheses. Multiplied together, the individual efficiencies yield the overall cumulative efficiencies in the boxes. For heat pumps, we have assumed an annual performance factor of 3.

Figure 2. Conversion efficiencies for different heating systems[26].

For some, hydrogen is the answer to every energy question. In reality, though, as Michael Liebreich, CEO of Bloomberg New Energy Finance, recently observed: «it is going to have to win, use-case-by-use-case, but it will not be easy.» He concludes that «hydrogen's role in the final energy mix of a future net-zero emissions world will be to do things that cannot be done more simply, cheaply and efficiently by the direct use of clean electricity and batteries.»[27] These sectors will probably include heavy industry, particularly chemicals, fertilizer, refineries and steel, as well as shipping, long-haul aviation, freight transport, pipeline and power infrastructure. Some of these sectors, like shipping, are «captive markets», which means that they really have no other option but to go for hydrogen-based fuels. It is a sector which could drive demand and help to bring down the costs of hydrogen and related fuels.

[26] Agora Energiewende and Frontier Economics, «The Future Cost of Electricity-Based Synthetic Fuels», 19 September 2018, p. 13. Available at: https://static.agora-energiewende.de/fileadmin2/Projekte/2017/SynKost_2050/Agora_SynKost_Study_EN_WEB.pdf. Accessed: 11 January 2021.

[27] Michael Liebreich, «Separating Hype from Hydrogen – Part Two: The Demand Side», 16 October 2020. Available at: https://about.bnef.com/blog/liebreich-separating-hype-from-hydrogen-part-two-the-demand-side/. Accessed: December 22, 2020.

Nonetheless, many companies are still pursuing hydrogen solutions for sectors that can be electrified. Japanese and Korean car manufacturers Toyota and Hyundai, as well as their home governments, have announced ambitious plans to scale up the production and sales of hydrogen cars. Plans to develop hydrogen-powered trains are underway in the UK, Austria, France and Japan. There are at least 37 projects across the world to blend hydrogen into the existing gas distribution network[28]. In some cases, these plans may still be pursued because companies have already committed a lot of money into research and development for several use-cases, and it might be costly to abandon such programs. In other cases, certain industrial actors (e.g., the gas lobby) are able to influence policymakers through lobbying and thus acquire public support (e.g., on hydrogen blending mandates)[29].

All in all, there are widely diverging estimates for the market potential of hydrogen. As Table 2 (below) shows[30], BNEF is the most bullish about hydrogen, estimating that it can meet up to 24% of final energy demand in 2050. Others, like Shell, estimate that hydrogen will only provide 2% of energy demand. The International Energy Agency (IEA) projects that demand for low-carbon hydrogen would be 11 EJ (or 75 million tonnes) by 2040, at least in its Sustainable Development Scenario[31]. At the moment, only 0.002% of all hydrogen currently produced is used as an energy carrier[32], so some of these projected demand figures imply a very rapid compound annual growth rate.

28 Carbon Brief, «In-depth Q&A: Does the world need hydrogen to solve climate change?» 30 November 2020. Available at: https://www.carbonbrief.org/in-depth-qa-does-the-world-need-hydrogen-to-solve-climate-change. Accessed: 22 December 2020.

29 Corporate Europe Observatory, «The hydrogen hype: Gas industry fairy tale or climate horror story?» 7 December 2020. Available at: https://corporateeurope.org/en/hydrogen-hype. Accessed: 22 December 2020.

30 This table is adapted, expanded and updated from: Pflugmann, Fridolin, and Nicola De Blasio. «The Geopolitics of Renewable Hydrogen in Low-Carbon Energy Markets», *Geopolitics, History, and International Relations* 12, no. 1 (2020): 9-44.

31 IEA, «World Energy Outlook 202», p. 294.

32 DNV GL, «Hydrogen as an energy carrier: An evaluation of emerging hydrogen value chains», 2018, p. 4. Available at: https://www.dnvgl.com/publications/hydrogen-as-an-energy-carrier-134607. Accessed: 12 January 2021.

	Study	**Annual demand (in EJ)**	**% of final energy**
Projected hydrogen demand in 2050	Hydrogen Council (2017)[33]	78 EJ	18%
	BNEF (2020)[34]	27-195 EJ	7-24%
	DNV GL (2020)[35]	24 EJ	6%
	Shell Sky Scenario (2018)[36]	9 EJ	2%
	IRENA Transforming Energy Scenario (2020)[37]	8 EJ	1%
For comparison, current annual demand for:			
Hydrogen	IEA (2019)	9-11 EJ	~0%
Oil	BP (2020)	193 EJ	33%
Natural gas	BP (2020)	141 EJ	24%

Table 2. Estimated market potential for hydrogen by 2050. Notes with Table 2: an exajoule (EJ) is 1 quintillion Joules (J). It is equivalent to roughly one day of the world's total final energy demand, or about 170 million barrels of oil[38]. Estimated annual hydrogen demand includes demand for hydrogen (of all colours) as an energy carrier and as a feedstock. Estimated share of hydrogen in final energy demand only covers the supply of hydrogen as an energy carrier.

33 Hydrogen Council, «Hydrogen – Scaling Up: A Sustainable Pathway for the Global Energy Transition», 2017, p. 20. Available at: https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf. Accessed: 12 January 2021.

34 https://assets.bbhub.io/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf

35 DNV GL, «Energy Transition Outlook 2020», September 2020, p. 100 and p. 103. Available at: https://download.dnvgl.com/eto-2020-download. Accessed: 12 January 2021.

36 Shell, «Shell Scenarios – Sky: Meeting the Goals of the Paris Agreement», numbers available at: https://www.shell.com/promos/business-customers-promos/numbers-behind-sky/_jcr_content.stream/1530643757647/c6daf2e0c93fd3d724f2804837d053fdd24e0553/shell-sky-scenario-data-2018.xlsx. Accessed: 12 January 2021.

37 International Renewable Energy Agency (IRENA), «Global Renewables Outlook: Energy Transformation 2050», April 2020, Abu Dhabi, IRENA. Available at: https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020. Accessed: 13 January 2021.

38 Hydrogen Council, «Hydrogen – Scaling Up: A Sustainable Pathway for the Global Energy Transition», 2017, p. 20. Available at: https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf. Accessed: 12 January 2021.

Towards an international hydrogen market

Hydrogen could well develop into an internationally traded commodity, just like crude oil, oil products, and natural gas. At present, the two biggest contenders to provide clean energy molecules in the future are blue and green hydrogen. In the case of blue hydrogen, international trade would still be required to ship it from producers to destination markets. In the case of green hydrogen, the single largest cost component is the cost of renewable electricity, so cheap electricity is an absolute prerequisite to be a competitive green hydrogen producer – cheap electrolysers alone do not suffice[39]. This creates an opportunity to produce green hydrogen at those locations in the world that have optimal renewable sources and export it from there to large demand centres.

Transportation options

Hydrogen's low energy density per volume makes it considerably more expensive to store and to transport. There are, however, different options for transport. According to the IEA, hydrogen transport via pipelines is the most cost-effective way if distances are less than 1.500 km, except for very small volumes, which may be delivered by trucks. For longer distances, and particularly for overseas trade, hydrogen could be moved across borders in ships or pipelines, either in pure form or chemically bound or converted into different fuels.

Pipelines

For countries with close geographic proximity, hydrogen may be shipped through pipelines, which is the cheapest method to deliver hydrogen in the long run. In North-western Europe, there exist already more than 4,500 km of hydrogen pipelines, including a 900 km hydrogen-pipeline network connecting the ports of Rotterdam (the Netherlands), Antwerp (Belgium), and Dunkirk (France). The US currently has 1,200 km of hydrogen pipelines[40].

[39] International Renewable Energy Agency (IRENA), «Green Hydrogen Cost Reduction: Scaling Up Renewables to Meet the 1.5°C Climate Goal», Abu Dhabi: IRENA, 17 December 2020. Available at: https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Dec/IRENA_Green_hydrogen_cost_2020.pdf. Accessed: 13 January 2021.

[40] Shell and Wuppertal Institute, «Shell Hydrogen Study: Energy of the Future?», 2017. Available at: https://www.shell.com/energy-and-innovation/new-energies/hydrogen. Accessed: 14 January 2021.

German gas pipeline operators have recently unveiled a blueprint for a 5,900 km hydrogen grid, dubbed «H2 Startnetz», based on converted natural gas pipelines. By 2030, some 1,200 km should be operational[41]. The new grid would also branch out into the Netherlands, where it could tie in to the existing H2 grid. While these plans sound ambitious, their size pales in comparison to the existing natural gas infrastructure. In Germany alone, the natural gas network is more than 530,000 km long[42].

One shortcut is to retrofit the existing natural gas transmission and distribution network so that it can carry hydrogen. A short-term and low-cost step could be to convert existing pipelines so they can ship a blend of natural gas and hydrogen (with up to 15% of hydrogen) with only modest modifications. Converting natural gas pipelines to deliver pure hydrogen is more challenging, however, since hydrogen can embrittle the steel and welds of the pipeline, poses threats of leakage and safety hazards, and requires costly compression technologies[43]. The suitability of existing pipelines for conversion to hydrogen must be assessed on a case-by-case basis and will depend on the type of steel used and the purity of hydrogen[44]. Nonetheless, the gas transmission industry is confident that such retrofitting is technically feasible, at affordable cost[45].

If such retrofitting would be technically feasible at affordable cost, Europe would benefit from its established gas transmission connections with Norway, Ukraine, Russia, and North Africa (Algeria and Libya). The upshot is that, akin to natural gas, hydrogen could be traded more on regional markets than on global markets. All in all, transporting hydrogen is an order of magnitude more expensive than transporting natural gas, which is itself

41 Bernd Radowitz, «German pipeline operators present plan for world's largest hydrogen grid», Recharge, 18 May 2020. Available at: https://www.rechargenews.com/transition/german-pipeline-operators-present-plan-for-world-s-largest-hydrogen-grid/2-1-810731. Accessed: 14 January 2021.

42 Gasunie, «Infrastructure in Germany: status quo», no date. Available at: https://www.gasunie.de/en/infrastructure/infrastructure-in-germany/statusquo. Accessed: 14 January 2021.

43 US Department of Energy, «Hydrogen Pipelines», no date. Available at: https://www.energy.gov/eere/fuelcells/hydrogen-pipelines. Accessed: 14 January 2021.

44 International Energy Agency (IEA), «The Future of Hydrogen», Paris: OECD/IEA, p. 77. Available at: https://www.iea.org/reports/the-future-of-hydrogen. Accessed: 11 January 2021.

45 Enagás, Energinet, Fluxys Belgium, Gasunie, GRTgaz, NET4GAS, OGE, ONTRAS, Snam, Swedegas, Teréga (2020). European Hydrogen Backbone, July 2020.

more expensive than shipping oil. It also remains to be seen whether hydrogen pipelines can compete with (ultra-)high voltage direct current transmission lines, which can also transport renewable power to demand centres. One of the projects currently in the planning stage is Sun Cable, which aims to connect a 10GW solar plant in South Australia with Singapore through a 3,750km subsea cable[46].

Shipping

Hydrogen could be moved across continents in ships in roughly three ways. A first way to ship hydrogen is to liquefy it. For that, the hydrogen molecules need to be cooled to minus 252°C at port terminals before being loaded onto highly insulated tanker ships. The liquefaction process consumes between around 25% and 35% of the initial quantity of hydrogen. This is considerably more energy than is required to liquefy natural gas into LNG, which requires cooling to minus 160°C and consumes around 10% of the energy content of the initial quantity of natural gas[47]. There is currently only one ocean-going ship in the world that can transport pure hydrogen, the *Hydrogen Frontier*, launched by Kawasaki in late 2019[48].

The second mode is by means of liquid organic hydrogen carriers (LOHC). LOHC refers to a slate of different organic compounds – e.g., methanol (CH3OH) or toluene (C7H8) – which can absorb and release hydrogen through a chemical reaction. LOHC can therefore serve as a storage and transportation medium for hydrogen. In a first step, the hydrogen is loaded into the LOHC molecule (a process called «hydrogenation»). The key advantage of using «carrier» molecules is they can be transported as liquids without the need for cooling. That is why they are sometimes called «liquid hydrogen batteries»[49]. LOHCs are very similar to crude oil and oil products and the existing oil transport

46 For more information, see: https://suncable.sg/.

47 International Energy Agency (IEA), «The Future of Hydrogen», Paris: OECD/IEA, p. 74. Available at: https://www.iea.org/reports/the-future-of-hydrogen. Accessed: 11 January 2021.

48 Robin Harding, «Japan launches first liquid hydrogen carrier ship,» *Financial Times*, 11 December 2019.

49 Aakko-Saksa, Päivi T., Chris Cook, Jari Kiviaho, and Timo Repo. «Liquid organic hydrogen carriers for transportation and storing of renewable energy–Review and discussion.» *Journal of Power Sources* 396 (2018): 803-823.

infrastructure could even be adapted to transport LOHCs[50]. After transport and storage, the hydrogen is liberated again from the LOHC («dehydrogenation»). The downside is that the conversions consume about 35-40% of the energy content of the hydrogen itself[51]. In addition, the carrier molecules can be expensive and need to be shipped back to their place of origin. In April 2020, a first demonstration shipment delivered hydrogen over a distance of 4,000 km, from Brunei to Japan, using toluene as carrier molecule.

The third way to ship hydrogen is to convert it into «synthetic fuels» or «synfuels», also referred to «electro fuels» or «e-fuels» if they are produced with hydrogen that is obtained through the electrolysis of water. The advantage of these e-fuels is that they can be used directly by the end consumer. Some major types of hydrogen-derived synfuels are ammonia, methanol, synthetic methane and synthetic liquids. The latter two are chemically identical to natural gas and oil products, respectively, and can be handled through the existing storage and distribution infrastructure. Producing them requires a source of CO2. If this source comes from direct air capture (DAC) or bioenergy with CCS, then such synthetic fuels can be carbon neutral. The first two types, ammonia and methanol, deserve a longer treatment.

Ammonia is sometimes referred to as «the other hydrogen» as it is, much like hydrogen, a carbon-free fuel (NH3). Hydrogen can be turned into ammonia by reacting with nitrogen from the air through the Haber-Bosch process. In other words, this carbon-free fuel can be made only with electricity, water and air. Ammonia has a much higher energy density compared to hydrogen and there is a well-established international trade in ammonia[52]. Ammonia is currently used as a feedstock, notably to make fertilisers, but it could also be used as decarbonization fuel, for instance in the shipping industry. The downside is that ammonia is toxic if leakages occur and is also a potential source of nitrogen oxide emissions. In September 2020, Saudi Arabia sent its first

50 Niermann, M., Sebastian Drünert, Martin Kaltschmitt, and Klaus Bonhoff. «Liquid organic hydrogen carriers (LOHCs)–techno-economic analysis of LOHCs in a defined process chain.» *Energy & Environmental Science* 12, no. 1 (2019): 290-307.

51 International Energy Agency (IEA), «The Future of Hydrogen,» Paris: OECD/IEA, p. 75. Available at: https://www.iea.org/reports/the-future-of-hydrogen. Accessed: 11 January 2021.

52 Royal Society, «Ammonia: Zero-Carbon Fertiliser, Fuel and Energy Store,» Policy Briefing, February 2020.

shipment of «blue ammonia» (made from natural gas with carbon capture and storage) to Japan where it was used to produce electric power.

Methanol, the simplest form of alcohol can be produced with hydrogen and CO2. With half the energy density of heating oil, this fuel would be very suitable for transport applications. The largest methanol synthesis plant is located in Iceland where it uses a combination of geothermal and hydropower to generate more than five million litres of methanol per year, part of which is exported to The Netherlands. As the energy comes from volcanoes, the green methanol is branded as «Vulcanol»[53].

Hydrogen hubs and valleys

While hydrogen could develop into a global commodity, the initial steps are likely to be more modest. At present, around 85% of all hydrogen is still produced and consumed on specific sites (e.g., refineries). Scaling up both supply and demand infrastructure for hydrogen could be achieved through industrial clusters, especially in different coastal areas. Various national hydrogen strategies are geared towards establishing such «hydrogen valleys» or hubs (e.g., ports or cities). From there, «hydrogen corridors» could be developed that connect regions with high renewable potential to demand centres.

Over time, then, the hydrogen market could come to mimic the natural gas market: North America largely self-sufficient, Europe importing some piped hydrogen from neighbouring countries, and Japan relying on sea-borne shipments of hydrogen. A key difference with natural gas, however, is that all major countries (including importers like Europe, Korea and Japan) will be «prosumers» – that is, they will both be producers and consumers of hydrogen and derived products. Another difference is that climate-conscious importers will want to have certificates or guarantees of origin to make sure that the hydrogen they get is of the right «colour». Here, there are some differences between different importers. Future Asian importers seem to be adhering to the «first grey, then blue, then green» hydrogen strategy, while Germany in particular is keen on leapfrogging directly to green hydrogen as quickly as possible.

53 Carbon Recycling International. Available at: https://www.carbonrecycling.is/. Accessed: 13 January 2021.

Key players in the geopolitics of hydrogen

In his influential work, *The Prize,* Daniel Yergin recounts the story of how oil became the world's most important energy source. He describes how oil is a game of «huge risks and monumental rewards»[54], both commercially and geopolitically. Hydrogen seems well-placed to become the «next great prize», a zero-carbon version of oil[55]. Just as in the petroleum industry, both private companies and countries are jockeying to control or at least gain a foothold in this emerging and potentially lucrative business, which has the potential to «fundamentally redraw the geography of global energy trade, create a new class of energy exporters, and reshape geopolitical relations and alliances between countries.»[56]

Who will be the hydrogen superpower?

The past two years in particular represent a potentially game-changing moment for the hydrogen industry. More than 20 governments have announced, drafted or published national hydrogen roadmaps or strategies over the past two years[57], including France (2018, updated in 2020), Japan and Australia (2019), and Norway, Germany, the EU, Portugal, Spain, Chile and Finland (all in 2020)[58]. Hydrogen plans have also been drawn up at other political scales, including states like California[59], regions like Northern England[60], and cities

[54] Daniel Yergin. «The Prize: The Epic Quest for Oil, Money and Power». New York: Simon and Schuster, 1991.

[55] Thijs Van de Graaf, «The Next Price: Geopolitical Stakes in the Clean Hydrogen Race,» *Oxford Energy Forum*, forthcoming.

[56] Thijs Van de Graaf, Indra Overland, Daniel Scholten, and Kirsten Westphal. «The new oil? The geopolitics and international governance of hydrogen.» *Energy Research & Social Science* 70 (2020): 101667.

[57] Kosturjak, Anthony, Tania Dey, M. Young, and Steve Whetton. «Advancing Hydrogen: Learning from 19 plans to advance hydrogen from across the globe.» *Future Fuels CRC* (2019).

[58] International Renewable Energy Agency (IRENA), «Green Hydrogen: A Guide To Policy-Making,» Abu Dhabi: IRENA, November 2020, p. 22.

[59] Renewable Hydrogen Roadmap, report prepared by Energy Independence Now for California Hydrogen Business Council, May 2018. Available at https://einow.org/rh2roadmap. Accessed: 12 January 2021.

[60] H21: North of England, report commissioned by Northern Gas Networks, Equinor and Cadent, 2018. Available at: https://www.northerngasnetworks.co.uk/event/h21-launches-national/. Accessed: 12 January 2021.

like London[61]. Some post-covid-19 recovery packages have also included support for (clean) hydrogen[62].

What these national and subnational plans reveal is that some countries are gearing up to become large-scale hydrogen importers (notably, Japan, Germany, and Korea), whereas others aspire to become large-scale exporters (notably, Australia, Chile, and Morocco) – sometimes referred to as «renewable energy superpower regions»[63]. Some fossil fuel exporting countries (like Saudi Arabia) are beginning to place tepid bets on hydrogen to possibly replace the export revenues from oil and gas, as more and more countries race to net zero. What is notable, though, is these are all middle powers. Most of the great and emerging powers of today (the US, China, Russia, India, and Brazil) can probably aim for hydrogen self-sufficiency.

In a recent paper, Harvard scholars Pflugmann and De Blasio draw the geopolitical map of renewable hydrogen. Based on three parameters – renewable energy resource potential, renewable freshwater endowment, and infrastructure potential (measured by the country's infrastructure score in the World Economic Forum's competitiveness index) – they identify five archetypical country positions, as shown in the Table below.

Role	**Renewable energy endowment**	**Freshwater availability**	**Infrastructure potential**	**Country examples**
«Export champions»	Very high	High	High	Australia, United States, Morocco, Norway
«Water-constrained producers»	Very high	Very low	High	Saudi Arabia, potentially China

[61] Element Energy Ltd. (2016), London: a capital for hydrogen and fuel cell technologies, report prepared for Hydrogen London. Available at: http://www.hydrogenlondon.org/hydrogen-londonprojects-events-and-publications/publications/. Accessed: 12 January 2021.
[62] International Energy Agency (IEA), «World Energy Outlook 2020,» Paris: OECD/IEA, footnote 8 at page 290.
[63] Michael Liebreich, «Separating Hype from Hydrogen – Part One: The Supply Side», 8 October 2020. Available at: https://about.bnef.com/blog/liebreich-separating-hype-from-hydrogen-part-one-the-supply-side/. Accessed: 13 January 2021.

«Major importers»	Low	High	High	Japan, Korea, parts of the EU
«Self-sufficient producers»	High	High	High	Turkey, Spain, Thailand
«Infrastructure-constrained producers»	High	Medium	Low	India, most parts of South America, potentially Russia

Table 3. Archetypical country roles play in renewable hydrogen markets Source: adapted from Pflugmann and De Blasio (2020)[64].

In a slightly more sophisticated approach, which takes into account additional variables like population density, business environment, political stability, and available surface area, a German-based consultancy identified no less than 23 countries with strong potential for Power-to-X (PtX) exports. They are depicted in Figure 3.

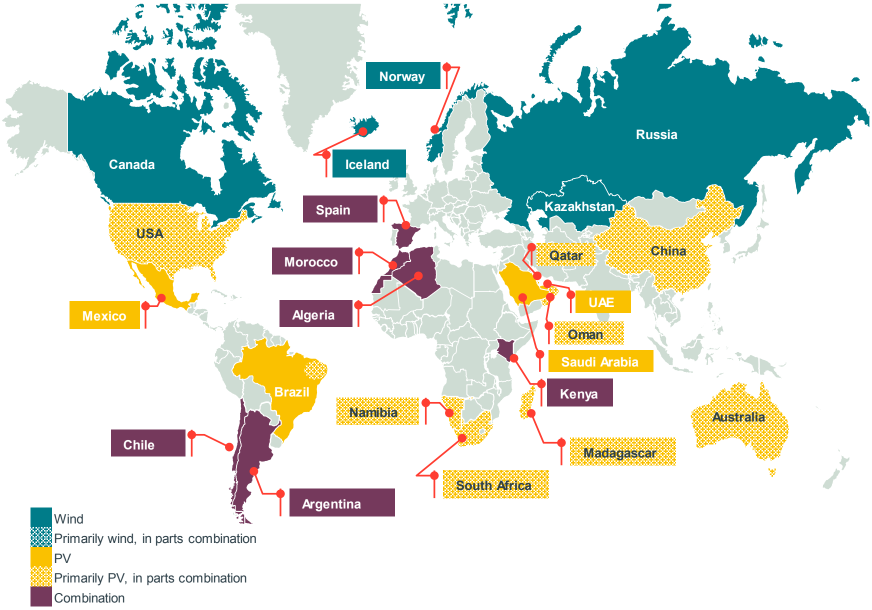
A comprehensive review of each of those players is beyond the remit of the current chapter. However, the following sections will home in on a selection of pioneering countries in developing markets for hydrogen (future importers) and in developing hydrogen production (future exporters). The two most promising regions for establishing international hydrogen trade are (1) the Asia-Pacific where Japan, Korea, Singapore, and China could emerge as major demand centres and Australia, Brunei, and New Zealand could become suppliers; and (2) Europe where countries such as Germany, The Netherlands, France and Belgium could source imports from Norway, North Africa and the Middle East.

Selected frontrunner countries

Japan

Japan is the absolute pioneering country when it comes to hydrogen. In 2017, it announced its ambition to become what it calls a «hydrogen-based society», envisaging widespread usage

64 PFLUGMANN, Fridolin, and Nicola De Blasio. «The Geopolitics of Renewable Hydrogen in Low-Carbon Energy Markets.» *Geopolitics, History, and International Relations* 12, no. 1 (2020): 9-44.



Source: Frontier Economics

Note: Illustrative presentation of the strongest RES potentials only; not an extensive list of all countries.

Figure 3. Countries with the strongest potential for PtX exports
Source: Frontier Economics (2018), p. 43[65].

of hydrogen, across all sectors of the economy[66]. This plan is backed up by considerable government investment in hydrogen technologies and infrastructure. In 2019, Japan elevated hydrogen to the top of the international agenda, by convening a G20 ministerial on hydrogen. To showcase its commitment to hydrogen, Japan built the Athlete's Village for the 2020 Tokyo Olympics (now postponed to 2021 due to covid-19) as a miniature hydrogen society. The Olympic torch was also fuelled by hydrogen. As the Governor of Tokyo noted: «The 1964 Tokyo Olympics left the Shinkansen high-speed train system as its legacy. The upcoming Olympics will leave a hydrogen society as its legacy»[67].

65 Frontier Economics, «International Aspects of a Power-to-X Roadmap: A report prepared for the World Energy Council Germany,» 18 October 2018. Available at: https://www.frontier-economics.com/media/2642/frontier-int-ptx-roadmap-stc-12-10-18-final-report.pdf. Accessed: 13 January 2021.

66 Japanese Ministry of Economy, Trade and Industry, «Basic Hydrogen Strategy,» 26 December 2017. Available at: https://www.meti.go.jp/english/press/2017/pdf/1226_003b.pdf. Accessed: 11 January 2021.

67 Fuel Cell & Hydrogen Energy Association, «Japan's Hydrogen Olympics», 25 May 2020. Available at: http://www.fchea.org/in-transition/2020/5/25/japans-hydrogen-olympics. Accessed: 12 January 2021.

Japan is currently importing all of its oil and gas needs, and it looks prepared to import a substantial share of its hydrogen needs as well. It has deployed a wide-ranging hydrogen diplomacy to find international partners to build a hydrogen supply chain, increase the scale of production, and decrease costs. Japan was the first country to begin looking for foreign partners that could export hydrogen. Its industrial stakeholders are engaging partners in Australia, Brunei, Norway and Saudi Arabia on hydrogen fuel procurement[68]. This has already led to some notable results. In June 2020, Japan received a first cargo of liquid organic hydrogen carrier (LOHC) from Brunei (based on natural gas), and is set to begin with trial shipments from Australia soon (based on coal). In September 2020, Saudi Arabia sent a first demonstration shipment of «blue ammonia» (made from natural gas with carbon capture and storage) to Japan where it will be used to produce electric power.

It looks like Japan will be once again a global gas market pioneer. It once helped to create a global market for liquefied natural gas (LNG). Now it looks set to repeat that success story with hydrogen[69]. The underlying goal is to achieve cost parity for hydrogen with LNG, the major fuel in Japan's electricity mix following the Fukushima nuclear disaster. To that end, Japan is looking to develop long-term supply agreements like those that spearheaded LNG trade[70].

European Union

The European Union, which is aiming for carbon neutrality by 2050, is also envisaging large-scale hydrogen imports. A European industry alliance has developed a plan to develop 2x40 GW of electrolysers by 2030, 40 GW in Europe and 40 GW in Europe's neighbourhood for export of hydrogen to the EU[71]. This proposal was reiterated in the EU's Hydrogen Strategy, which was released in July 2020, and included the ambitious goal of installing 40 GW

[68] Monica Nagashima, «Japan's Hydrogen Strategy and Its Economic and Geopolitical Implications», IFRI, October 2018. Available at: https://www.ifri.org/sites/default/files/atoms/files/nagashima_japan_hydrogen_2018_.pdf. Accessed: 12 January 2021.

[69] Thijs Van de Graaf, Indra Overland, Daniel Scholten, and Kirsten Westphal. «The new oil? The geopolitics and international governance of hydrogen.» *Energy Research & Social Science* 70 (2020): 101667.

[70] Japanese Ministry of Economy, Trade and Industry, «Basic Hydrogen Strategy,» December 26, 2017. Available at: https://www.meti.go.jp/english/press/2017/pdf/1226_003b.pdf. Accessed: 11 January 2021.

[71] https://www.hydrogen4climateaction.eu/2x40gw-initiative.

of renewable hydrogen electrolysers in the EU by 2030[72]. Europe has a clear preference for green hydrogen, in contrast to emerging Asian demand centres (Japan, Korea and China), which bet on grey, blue and green hydrogen in the coming decades to scale up the market[73].

Germany's national hydrogen strategy not only foresaw €7 billion earmarked for domestic production of green hydrogen, but also €2 billion for overseas production. [74] Germany is currently exploring imports from countries as diverse as Morocco, the Democratic Republic of Congo (DRC), and even remote Australia. It may make sense, however, to focus first on imports from southern and eastern Europe, as well as Ukraine. After all, those countries are integrated into the common energy market at the regulatory level (e.g., through the European Energy Community), and in many cases there are already existing (gas) infrastructure networks that could be used for hydrogen trade[75].

Some countries within the EU could develop into net hydrogen exporters, though. The hydrogen strategy of Portugal, for instance, is benchmarked on the country becoming a hydrogen exporter by 2030. The country can take advantage of very competitive prices for renewable electricity production and a strategic geographical location for export. It has already signed an agreement with The Netherlands to export green hydrogen from the port of Sines to Rotterdam, a project that has been designed as a strategic priority by the EU[76]. Spain, too, has ambitions of becoming an exporter of green molecules. Spanish power company Iberdrola and fertilizer maker Fertiberia have unveiled a plan for

72 EUROPEAN COMMISSION, «A hydrogen strategy for a climate-neutral Europe», Brussels, 8 July 2020.

73 NOUSSAN, Michel, Pier Paolo Raimondi, Rossana Scita, and Manfred Hafner. «The Role of Green and Blue Hydrogen in the Energy Transition—A Technological and Geopolitical Perspective.» *Sustainability* 13, no. 1 (2021), p. 297.

74 The German Federal Government, «The National Hydrogen Strategy,» Federal Ministry for Economic Affairs and Energy, June 2020. Available at: https://www.bmbf.de/files/bmwi_Nationale%20Wasserstoffstrategie_Eng_s01.pdf. Accessed: 11 January 2021.

75 Kirsten Westphal, Susanne Dröge, and Oliver Geden, «The international dimensions of Germany's hydrogen policy,» SWP, Berlin, June 2020. Available at: https://www.swp-berlin.org/fileadmin/contents/products/comments/2020C32_HydrogenPolicy.pdf. Accessed: 12 January 2021.

76 Memorandum of understanding between Portugal and the Netherlands concerning green hydrogen. 17 August 2020. Available at: https://www.government.nl/documents/publications/2020/09/23/memorandum-of-understanding-between-the-netherlands-and-portugal-concerning-green-hydrogen. Accessed: 12 January 2021.

large-scale exports of green ammonia[77]. These two countries, as well as Italy, could develop into a significant hydrogen gas transit countries, importing hydrogen from solar and wind power in North Africa and exporting it to other European countries through existing gas infrastructure[78].

Australia

Few countries are better positioned than Australia to become a world-class exporter of green hydrogen and derived molecules (ammonia, methanol), thanks to its massive renewable energy endowment and coal reserves. Australia's National Hydrogen Strategy, released in late 2019, prioritizes to build a competitive hydrogen export industry to serve the markets of Japan, Korea, Singapore and Taiwan[79].

The Asian Renewable Energy Hub, an enormous green hydrogen project is now in advanced planning stages. It aims to build the world's biggest solar and wind farm (and indeed the largest power station on earth) on a 6,500 square km site in the Pilbara, a remote desert region in Western Australia[80]. Once finished, the installation will have a 23GW capacity to churn out green hydrogen and green ammonia, the bulk of which would then be exported to Asia[81].

Chile

Another sunlit nation, Chile, is also aiming to become a green hydrogen and ammonia exporter, mostly to serve emerging markets in Europe, at least initially. Chile can boast one of the best solar resources in the world in regions such as the Atacama desert, with more than 3,000 sun hours and less than 2 millimetres of rainfall per year. The country is taking a more modest

[77] Laura Millan Lombrana, «Spain Could Become Green-Ammonia Exporter With Hydrogen Project», 28 October 2021. Available at: https://www.bloomberg.com/news/articles/2020-10-28/spain-could-become-green-ammonia-exporter-with-hydrogen-project. Accessed: 12 January 2021.

[78] SNAM, «The Hydrogen Challenge: The potential of hydrogen in Italy», Position Paper, 10 October 2019. Available at: https://www.snam.it/it/hydrogen_challenge/repository_hy/file/The-H2-challenge-Position-Paper.pdf. Accessed: 12 January 2021.

[79] Commonwealth of Australia, «Australia's National Hydrogen Strategy», 2019. Available at: https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf. Accessed: 13 January 2021.

[80] Jamie Smith, «Australia backs desert project to export green hydrogen to Asia», *Financial Times*, 22 October 2020.

[81] Asian Renewable Energy Hub. Available at: https://asianrehub.com/about/. Accessed: 13 January 2021.

start compared to Australia: it hopes to reach 5GW of electrolysers capacity by 2025, produce the world's cheapest hydrogen by 2030, and become one of the top 3 hydrogen fuel exporters by 2040[82]. The Chilean proposition is based on a combination of photovoltaic (PV) and concentrated solar power (CSP), which would give a combined capacity factor of more than 50%, and would be able to produce hydrogen at a levelized cost of around $2.7/kg according to IRENA,[83] although McKinsey places it at a level of $1.3/kg[84]. According to Energy Minister Juan Carlos Jobet, the country could be exporting $30bn of green hydrogen by 2030[85]. That is about the size of current copper exports, the current linchpin of Chile's economy.

Geopolitical dimensions of hydrogen

For decades, the geopolitics of energy has revolved around fossil fuels, and oil in particular[86]. As new energy sources, particularly solar and wind, have achieved spectacular cost reductions, the contours of a new energy order begin to emerge. For large chunks of our energy demand, electrification will be the most efficient route to abate emissions. The decarbonization of other sectors, however, will require different solutions, based on molecules rather than electrons. Many of the pathways towards carbon-neutral molecules involve hydrogen, either in pure form (H2) or as a compound (for example, ammonia or NH3).

Here, I identify and describe six geopolitical dimensions of hydrogen:

- First, hydrogen is already triggering a race for technological leadership. For strategic reasons, countries want to be a tech-

[82] Etienne Gabel, «Big ambitions: How Chile aims to be among the largest exporters of green hydrogen in the world», IHS Markit, 22 December 2020. Available at: https://ihsmarkit.com/research-analysis/big-ambitions-how-chile-aims-to-be-among-the-largest-exporters.html. Accessed: 13 January 2021.

[83] IRENA, «Hydrogen: A Renewable Energy Perspective», Report prepared for the 2nd Hydrogen Energy Ministerial Meeting in Tokyo, Japan, September 2019, p. 36. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf. Accessed: 11 January 2021.

[84] Gobierno de Chile, «Estrategia Nacional De Hidrógeno Verde», November 2020. Available at: https://energia.gob.cl/sites/default/files/estrategia_nacional_de_hidrogeno_verde_-_chile.pdf. Accessed: 13 January 2021.

[85] Benedict Mander, «Chile seeks to turn solar boom into green hydrogen bonanza», *Financial Times*, 31 August 2020.

[86] Thijs Van de Graaf and Benjamin K. Sovacool, *Global Energy Politics*, Polity, 2020.

nology maker, not a technology taker, in key technologies of the future – and hydrogen is no exception to that.

- Second, countries are in parallel also deploying new (green) industrial policies, often supported by (protective) trade policies. Hydrogen is an important element of discussions around industrialization (in developing and emerging economies) and around preventing delocalisation of industries or even reshoring «lost» industries (in industrialised economies).
- Third, hydrogen raises both threats and opportunities to fossil fuel producer countries. Some of them, like Saudi Arabia or the UAE, seem interested in joining the hydrogen bandwagon. While this may make them more supportive actors in the global climate regime, there is a risk that they pursue the blue hydrogen or blue ammonia route, which in the long term is not compatible with net zero targets.
- Fourth, hydrogen could foster new interdependencies between countries. As a result, political relations and alliances could shift, and new security of supply risks may emerge.
- Fifth, hydrogen infrastructures are capital intensive but can take completely different routes. In a carbon-constrained future, the key contenders will be blue and green hydrogen. Overinvestment in the blue hydrogen pathway could, however, result in carbon lock-in (thus posing a threat to climate mitigation) or result in stranded assets (if climate mitigation policies are strongly pursued).
- And sixth, geopolitical competition is also evident in the sphere of market regulation and governance. Countries and companies clash over issues like technical standards, certification schemes and guarantees of origin. There is no single institutional venue in global governance where hydrogen is discussed, opening space for inter-institutional competition.
- The following sub-sections will discuss each of those dimensions in turn.

The race for technological leadership

Controlling the value chains of low-carbon energy technologies is vital for every country's economic competitiveness, national security, and energy independence. Early movers in the hydrogen industry might be able to sell their technology to the rest of the world. Technology leadership might be developed around many aspects of the hydrogen value chain, including membranes for fuel cells, electrolysers, or high-pressure storage tanks.

The anticipated boom in hydrogen could create large new markets, and spur a race for technological leadership. McKinsey and the Hydrogen Council estimate that, by 2050, sales of hydrogen as a commodity and related equipment (such as electrolysers, hydrogen refuelling stations, and fuel cells) could be worth 2.5 trillion dollars per year, and generate 30 million jobs[87]. Bloomberg New Energy Finance (BNEF) believes hydrogen could open up 11 trillion dollars of investment opportunity over the next 30 years[88].

As such, hydrogen is just another battleground for technological and economic supremacy between the established and rising powers of this world. Just as the US ascent to global supremacy in the 20th century was inseparable from oil, countries are now vying to control the key energy technologies of the future: not just hydrogen, but also solar, batteries, digital networks, electric vehicles, and so on. Countries have a strategic interest to be a technology maker, not a technology taker in these critical areas.

This geo-economic calculus is already influencing hydrogen policies. Germany's massive green hydrogen push, for example, is a clear bid to outcompete China, mindful of the painful experience of losing its solar PV manufacturing industry to China a few years ago[89]. While China has done a lot to drive down the unit costs of photovoltaics and wind, it has also acquired dominant positions in the value chains of these and other energy technologies, like electric vehicles and rare earths. China produces over a third of wind turbines, more than half of all electric vehicles and over 70% of the world's solar panels[90].

Electrolysers have the same kind of modularity as PV solar panels or batteries and could thus experience the same kind of price deflation that we have seen for those technologies. BNEF estimates that, as of 2019, electrolysers were already 83% cheaper to produce in China than in Western countries[91]. Admittedly, Chinese manufacturers focus on the more standard alkaline

[87] Hydrogen Council (2017). Hydrogen scaling up: A sustainable pathway for the global energy transition. November 2017.

[88] BNEF (2020). Hydrogen Economy Outlook. March 30, 2020.

[89] Sören Amelang (2020). Europe vies with China for clean hydrogen superpower status. Clean Energy Wire, July 24, 2020. https://www.cleanenergywire.org/news/europe-vies-china-clean-hydrogen-superpower-status.

[90] Sarah Ladislaw and Nikos Tsafos, «Beijing is Winning the Clean Energy Race», *Foreign Policy*, 2 October 2020.

[91] BNEF (2020). Hydrogen Economy Outlook. March 30, 2020.

electrolysers, which are less flexible than the solid oxide and proton exchange membrane technologies that European firms have focused on. But in many respects it looks like the race has already been run. It will be hard for European manufacturers to beat China on costs.

The race for technology leadership is clear in many countries and sectors. Consider automotive: Japanese car makers Honda and Toyota are betting that fuel cell vehicles will triumph over batteries, especially in terms of range, while Chinese car makers are making big strides in electric vehicles, and German car makers have long focused on making diesel-powered combustion engines more efficient. In many cases, public money is underpinning efforts to deploy hydrogen value chains, making this even more the territory of geo-economic competition. That is why the EU Commission has announced that it will shortly launch an EU Hydrogen Alliance in a recent document on a «new industrial strategy for Europe»[92]. In a similar vein, the EU has recently launched an EU Battery Alliance and a Raw Materials Alliance to try and catch up with China.

Just as other parts of the clean energy transition, hydrogen value chains are also mineral and metal intensive. Around 30 raw materials are needed to produce fuel cells and hydrogen storage infrastructure, 13 of which are deemed critical by the EU: cobalt, magnesium, rare earth elements, platinum, palladium, borates, silicon metal, rhodium, ruthenium, graphite, lithium, titanium and vanadium. Figure 4 depicts some of the relevant raw mate-

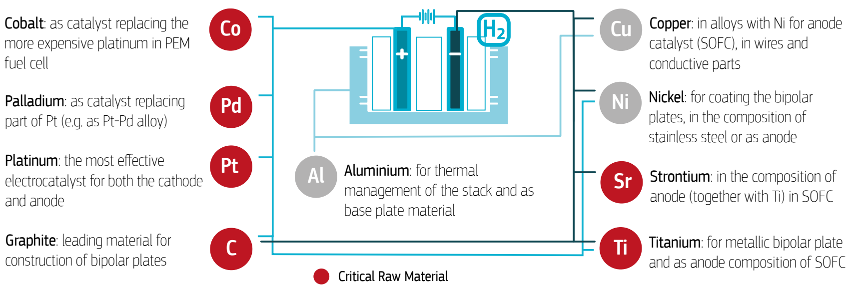


Figure 4. Relevant raw materials used in fuel cells Source: EU Commission (2020)[93].

[92] EU Commission (2020). A New Industrial Strategy for Europe. COM (2020) 102 final. 10 March 2020.

[93] European Commission, «Critical Raw Materials for Strategic Technologies and Sectors in the EU: A Foresight Study», 3 September 2020. Available at: https://ec.europa.eu/docsroom/documents/42882. Accessed: 14 January 2021.

rials that are needed to produce fuel cells. In particular, fuel cells rely heavily on platinum-based catalysts, with platinum making up about half of the cost of a fuel cell stack.

Geo-economic competition

The emergence of inter-continental hydrogen value chains will also intensify competition between countries about the siting of energy-intensive and trade-exposed industries. Countries with a lot of potential to make hydrogen from indigenous resources (either renewables or fossil fuels) might opt for expanding their value chains into energy-intensive industries such as chemicals and steel, instead of simply exporting hydrogen to industrialised countries. The model country that is often named in this regard is Iceland, which used to be one of the poorest countries in Europe, but was able to industrialise and attract energy-intensive (export) industries like aluminium smelting, ferro-silicon production, and digital data processing thanks to its abundant and cheap hydropower and geothermal energy. One could even argue that Iceland is exporting its cheap energy as high-value data[94].

In a similar vein, the Grattan Institute, an Australian think-tank launched a report in May 2020 entitled «Start with Steel», arguing that Australia should use its renewable energy abundance not to export hydrogen as an energy carrier but to attract new manufacturing industries in steel and ammonia production[95]. This renewable-led green industrialisation, it is argued, would enable a «just transition» for workers currently employed in carbon-intensive sectors.

In many instances, however, developing countries are still only regarded as the providers of raw materials and energy resources to power the industrial centres of the rich world, not as destinations for the relocation of industries with high value-added. Some of the hydrogen trade schemes that are currently being floated smack of «green colonialism»[96]. One such example is a

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[94] Lucas Laursen, «Iceland Exports Energy as Data», *MIT Technology Review*, 11 April 2012. Available at: https://www.technologyreview.com/2012/04/11/186812/iceland-exports-energy-as-data/. Accessed: 14 January 2021.

[95] «Start with Steel: A practical plan to support carbon workers and cut emissions». Available at: https://grattan.edu.au/report/start-with-steel/. Accessed: 14 January 2021.

[96] Thijs Van de Graaf, Indra Overland, Daniel Scholten, and Kirsten Westphal. «The new oil? The geopolitics and international governance of hydrogen.» *Energy Research & Social Science* 70 (2020): 101667.

plan by German turbine makers and gas companies to export green hydrogen from hydropower in the Democratic Republic of Congo (DRC) to Germany[97]. What makes this project so contentious is that only 10% of the population of the DRC has access to electricity[98]. Nonetheless, the German development agency is sponsoring the creation of an «atlas» with favourable locations in Africa for green hydrogen production[99].

Industrial policy is no longer a taboo in the industrialized world. Supply-chain shocks and economic dislocation precipitated by the Covid-19 pandemic have led even the most market-oriented governments to consider more dirigiste policies inconceivable just a few years ago. There are growing calls for the reshoring of important industries, not just in pharmaceutical and medical industries, but also in energy industries. Whereas China has its «Made in China 2025» plan, Europe now tries to stand up and develop its own industrial planning in areas like batteries, hydrogen, and raw materials.

The future of petrostates

When it comes to the impact of hydrogen on fossil fuel producer countries, sometimes also referred to as «petrostates», there are basically two schools of thought[100]. One school sees hydrogen, and green hydrogen in particular, as an opportunity for import-dependent countries to replace fossil fuel imports from often geopolitically unstable regions in the world, and to diversify the energy supply. Another school sees it the other way around: a sudden drop in export revenues due to fuel switching could be geopolitically destabilising for producer countries, with con-

[97] Pauline Bax, «Congo Hydrogen Plant Being Considered by European Turbine Makers», *Bloomberg Green*, 21 August 2020. Available at: https://www.bloomberg.com/news/articles/2020-08-21/congo-hydrogen-plant-being-considered-by-european-turbine-makers. Accessed: 14 January 2021.

[98] Jonathan Gaventa, «Will the dash for hydrogen benefit sub-Sahara Africa?» *Energy Monitor*, 21 October 2021. Available at: https://energymonitor.ai/technology/hydrogen/will-the-dash-for-hydrogen-benefit-sub-saharan-africa. Accessed: 14 January 2021.

[99] For more information, see: https://www.sasscal.org/atlas-of-green-hydrogen-generation-potentials-in-africa/. Accessed: 14 January 2021.

[100] Noé Van Hulst, «An International Perspective on Clean Hydrogen», Nederlandse Vereniging voor de Verenigde Naties, 22 April 2020. Available at: https://nvvn.nl/an-international-perspective-on-clean-hydrogen/. Accessed: 15 January 2021.

comitant effects on migratory flows and international security[101]. Blue and green hydrogen and ammonia could throw a lifeline to producer countries and even give them a buy-in in global climate discussions, where they are now often at loggerheads with climate frontrunner countries who want to accelerate the energy transition and quickly move away from fossil fuels[102].

Several countries identified as candidates to become hydrogen export champions already play a big role in today's fossil fuel energy system. This is the case, for instance, for Australia, the United States and Saudi Arabia. Hydrogen would allow these countries «to retain the basic business model of the oil era which is based on cheap production of a universally used fuel for transport and heat generation»[103]. For some of these established energy players like Saudi Arabia, it seems unlikely that they will be able to generate as many rents from hydrogen or ammonia exports as they get from oil and gas exports. They face the dilemma that any exports of green molecules would face competition from, and potentially destroy demand, for their much more lucrative fossil fuel exports. Contrary to the oil business, in a hydrogen economy, petrostates will have to compete with a broader set of countries – roughly the countries situated in the world's sunbelt and some places with abundant wind such as Argentina and Chile. If they can become first movers, they might lock-in some of the emerging hydrogen demand for a long period, especially if they can agree on long-term supply contracts (which ensure the viability of investments)[104].

Needless to say, in any scenario that is compatible with the Paris climate goals, the rise of hydrogen goes hand in hand with a decline of fossil fuel markets. The flipside of the investment opportunities that hydrogen presents is the revenues foregone by current oil and gas producers, possibly also in the order of billions or trillions of dollars. While the coal industry has felt the knock-on effects of ultra-competitive renewables early on, espe-

101 IRENA, *A New World: The Geopolitics of the Energy Transformation*, Abu Dhabi: IRENA.

102 BRADSHAW, Michael, Thijs Van de Graaf, and Richard Connolly. «Preparing for the new oil order? Saudi Arabia and Russia.» *Energy Strategy Reviews* 26 (2019): 100374.

103 Axel Michaelowa and Sonja Butzengeiger, «Breakthrough of Hydrogen Technologies until 2030: Chances and Risks for Gulf Countries, International Policy Implications», in EDA Insights, September 2019. Available at: https://eda.ac.ae/docs/default-source/Publications/eda-insight_hydrogen-economy_en_final.pdf?sfvrsn=2. Accessed: 15 January 2021.

104 Michaelowa and Butzengeiger, 2019.

cially in Europe, the oil and gas industry has long been relatively insulated from these cheaper electrons, which served different markets anyway. The electrification of several end-use sectors (e.g., personal vehicles, home heating) has already begun to change this picture. Over time, cheaper hydrogen has the potential to become a competitor for oil and gas in some of their last vestiges: high-heat industrial processes, heavy-road transport, shipping and aviation.

Several oil and gas rich countries in the Middle East are banking on hydrogen to maintain their position as key energy suppliers to the world. The desert Kingdoms of the Persian Gulf (Saudi Arabia, UAE, Kuwait) have ample solar potential, underground storage space, and experience in energy molecule trade. They could harness pipeline and shipping infrastructure, including ports, to position themselves as major hydrogen exporters. Of course, their ambitions might be constrained by lack of sufficient freshwater. A solution here could be desalination plants, but these would of course also consume a sizeable share of the solar electricity or natural gas that went in to produce the green or blue hydrogen respectively.

Not all petrostates have the renewable potential to become major clean hydrogen exporters, or simply lack interest. Russian state-controlled company Gazprom, for example, is keen on keeping its natural gas exports in place, and is of the opinion that its gas should be converted into (blue) hydrogen only at the point of consumption, for instance when it reaches the shores of Germany. While there is a technical case to be made in support of Gazprom's position, it is very clear that this is by far the easiest way for the Russian state-led gas giant to stick to its current business model[105].

New interdependencies

If hydrogen becomes a globally traded commodity, it could give rise to new trading relationships and new interdependencies. Just like in the early days of the LNG market, bilateral deals and agreements are now being forged around hydrogen trade,

105 Kirsten Westphal, Susanne Dröge, and Oliver Geden, «The international dimensions of Germany's hydrogen policy», SWP, Berlin, June 2020. Available at: https://www.swp-berlin.org/fileadmin/contents/products/comments/2020C32_HydrogenPolicy.pdf. Accessed: 12 January 2021.

including Japan-Australia, Germany-Morocco, Norway-Korea, Belgium-Oman, Netherlands-Portugal, etc. Over time, these bilateral deals could give way to new energy trade relations, new shipping lanes and new trade routes. This is already influencing foreign policies around the world, and might also inform strategic planning by defence specialists.

The hype around hydrogen is already given a new focus to «energy diplomacy», traditionally defined as «government-related foreign activities that aim to ensure a country's energy security while also promoting business opportunities related to the energy sector»[106]. For most countries, energy diplomacy was geared at securing reliable and affordable imports of fossil fuels. Nowadays, diplomats and officials at some foreign offices are also spending time at exploring secure future imports of hydrogen and hydrogen-derived gases and liquids. The Dutch government has even appointed a special «hydrogen envoy» for this purpose, Mr. Noé Van Hulst.

Japan's diplomats and industrial stakeholders are engaging Australia, Brunei, Norway, and Saudi Arabia on hydrogen fuel procurement. Germany has signed a cooperation agreement with Morocco on methanol production from hydrogen, South Korea has its eyes on Norway, the Netherlands is targeting Portugal as a potential supplier of hydrogen, and industrial players in Belgium are looking towards Oman and Chile for large-scale hydrogen imports. If Europe will begin to import hydrogen from countries like Morocco and Oman, this will elevate the strategic importance of those countries for the EU.

If the current trend toward bilateral partnerships continues, the market could start from a highly fragmented base, mimicking the experience with the initial phases of the LNG market. The first LNG projects were subject to inflexible, bilateral, long-term contracts with oil-indexed prices – and were therefore sometimes referred to as «floating pipelines.» Japan spearheaded the development of the LNG market by emerging as the first big buyer. Its commitment to large-scale hydrogen imports could make it, once again, global gas market pioneer, this time in hydrogen.

One of the key differences with trade in crude oil or natural gas is that hydrogen trade will be less asymmetric. It is technically possi-

[106] Griffiths, Steven, «Energy diplomacy in a time of energy transition», *Energy Strategy Reviews* 26 (2019): 100386.

ble to produce hydrogen almost everywhere in the world. The fact that many countries could become «prosumers» (both producers and consumer of hydrogen) and that hydrogen can be stored makes it almost impossible for exporters to «weaponise» hydrogen trade or for importers to be trapped by a small cartel of suppliers. Yet, hydrogen trade will not be as reciprocal as cross-border trade in electricity, where electrons actually travel both ways depending on supply and demand conditions on both sides of the border. Still, international trade in hydrogen will boost the energy security of importers as it will provide a back-up to the electricity system. For energy import-dependent countries, it could also improve the diversity of energy sources and increase energy security. Since hydrogen is storable, countries could think about creating strategic stockpiles of hydrogen to guard themselves against any unforeseen disruptions in the supply – much like the multilateral oil stock regime that is overseen by the International Energy Agency (IEA).

At the same time, the prospect of large-scale hydrogen imports could also create new maritime security concerns. Hydrogen is a highly flammable and explosive material. Some of its derivates like ammonia are toxic. Risks and hazards from a marine LNG or oil tanker spill are well known. LNG spills pose a threat of asphyxiation and cryogenic burns. Studies have pointed out that the risk of explosion of LNG tankers is quite small, reducing the risk that they become terrorist targets[107]. Oil tankers have been torpedoed, and these incidents have shown that, much like LNG tankers, they are not «floating bombs». They can catch fire, sure, but they do not lead to massive blow-outs. This might be different for liquid hydrogen-carrying ships, where the high flame velocity of hydrogen creates the risk of detonation and a shockwave[108]. Scaling up such trade along fixed supply routes could thus create additional maritime security risks, including for narrow waterways and port cities. The devastation caused by the ammonium nitrate carrying ship that was docked at the port of Beirut and exploded in August 2020 is a reminder of the grave security risks that highly inflammable substances such as hydrogen and ammonia pose.

[107] US GAO, «Maritime security: public safety consequences of a terrorist attack on a tanker carrying liquefied natural gas need clarification : report to Congressional requesters», February 2007. Available at: https://www.gao.gov/new.items/d07316.pdf. Accessed: 15 January 2021.

[108] Lloyd's Register, «World first for liquid hydrogen transportation», 23 October 2020. Available at: https://www.lr.org/en/insights/articles/world-first-for-liquid-hydrogen-transportation/. Accessed 15 January 2021.

As energy trade flows change, so will security partnerships. Just look at the impact of the shale revolution on the US relationship with the Persian Gulf. The US is increasingly disengaging from the Middle East. This foreshadows what is coming. As the ET progresses, key oil transit routes like the Strait of Hormuz become less important for global energy security. We will also see the weakening of alliances built on fossil fuels. OPEC as an organisation has basically ceased to exist – key decisions are now taken elsewhere. There's already fierce conflict between oil producers over market share[109]. This will only intensify if oil and gas demand declines because of fuel switching to renewables and green hydrogen.

Carbon lock-in and stranded assets

Even if ambitious hydrogen plans are being developed out of a genuine concern to meet mid-century net zero emission goals, there are clear risks that countries and companies pursue plans that lock in further use of unabated fossil fuels, a phenomenon known as «carbon lock-in». For instance, German plans to import large volumes of green hydrogen from North African countries could very well lead to a situation whereby solar and wind electricity is exported, while fossil fuels provide local electricity supplies[110]. Demand for renewable electricity in the countries of origin must first be met before exports of hydrogen can truly be «green».

There are also risks involved in further pouring billions of dollars in expanding value chains for blue hydrogen. It is routinely argued that blue hydrogen is needed as a bridge to green hydrogen, much in a similar way as the argument about natural gas as a «bridge fuel». Policymakers in Germany, the European Commission, and elsewhere seem to converge on the view that, in the end, green hydrogen should dominate supply since blue hydrogen is not carbon neutral.

However, blue and green hydrogen have totally distinct value chains. They are like parallel worlds. The blue hydrogen world

[109] VAN DE GRAAF, Thijs. «Battling for a shrinking market: oil producers, the renewables revolution, and the risk of stranded assets». In *The geopolitics of renewables*, pp. 97-121. Springer, Cham, 2018.

[110] Kirsten Westphal, Susanne Dröge, and Oliver Geden, «The international dimensions of Germany's hydrogen policy», SWP, Berlin, June 2020. Available at: https://www.swp-berlin.org/fileadmin/contents/products/comments/2020C32_HydrogenPolicy.pdf. Accessed: 12 January 2021.

is populated by oil and gas companies who are looking at CCS to make low-carbon hydrogen – CCS could even become a new form of income for depleted oil and gas fields, like those of the North Sea. Green hydrogen is more the terrain of utilities, grid operators, and electrolyser manufacturing companies. Producing hydrogen via electrolysers can improve the business case of renewables and help balance the grid. Those two industry schemes, blue and green, are set to collide head-to-head.

The «first-blue-then-green» hydrogen strategy is risky, because it could set off a self-reinforcing cycle of «socio-technical lock-in». It's not uncommon for blue hydrogen production facilities to have economic life cycles of 25 years or more. Asset stranding could occur if the market for blue hydrogen dissipates before this period, for example if the costs of green hydrogen have come down faster than expected. and lock in. Blue hydrogen investments could also give rise to the development of a very costly hydrogen transportation infrastructure, which will not be suitable for a switch to green hydrogen, since blue and green hydrogen will be made at very different geographic locations. Any expansion of blue hydrogen production will create vested interests and new incumbents, which are likely to resist the shift to green hydrogen.

Shaping and governing the market

Geopolitical tensions might also erupt is with regard to the regulations and governance of international hydrogen markets. One area where a stand-off could occur is with regard to technical standards. The EU Hydrogen Strategy mentions explicitly the aim to «strengthen EU leadership in international fora for technical standards, regulations and definitions on hydrogen»[111]. These standards comprise safety and sustainability standards for both hydrogen molecules themselves, but also for all hydrogen-related transport, handling, storage, and end-use infrastructure. Defining standards can provide a competitive edge to those companies who already master and control standardized technologies. In recent years, China has become much more proactive in this field, including at major standard-setting bodies like the International Standard Organization[112].

[111] European Commission, «A hydrogen strategy for a climate-neutral Europe», Brussels, 8 July 2020, p. 23.
[112] John Seaman, «China and the New Geopolitics of Technical Standardization», IFRI, January 2020. Available at: https://www.ifri.org/sites/default/files/atoms/files/

Another aspect of shaping the market pertains to certification of hydrogen. A molecule of grey hydrogen is identical to a molecule of green hydrogen. Therefore, a certification system is needed that allows end users to know the carbon content and quality of hydrogen. Schemes that also track the origins of hydrogen are usually referred to as «guarantees of origin»[113]. At present, there is not a universally accepted definition of green hydrogen, even though international hydrogen trade would benefit from a harmonised system of guarantees of origin[114]. The carbon content of hydrogen will become the «new currency», in the words of Jorgo Chatzimarkakis from Hydrogen Europe, a European trade association for the hydrogen industry[115].

These aspects could turn into trade frictions. It is likely that, over time, key importers such as the EU will define restrictions that only allow renewable-energy derived (green) hydrogen to be imported without carbon penalties[116]. Hydrogen could become one of the major battlefields for future carbon trade wars. We are beginning to see the first manifestations of this. In October 2020, the French government pressured Engie, a utility, to withdraw from a $7 billion deal to procure LNG from fracked wells in Texas. Allegedly, Paris did so out of concern that the LNG would be too dirty because of upstream methane leaks[117]. As the EU and others are moving towards adopting carbon border adjustment mechanisms to address the issue of «carbon leakage» (delocalisation of energy-intensive industries to jurisdictions with lax carbon regulations), exporters of blue hydrogen might be put at a disadvantage compared to exporters of green hydrogen.

There will also be geo-economic competition over monetary benchmarks in hydrogen trade. Current trade in oil is predom-

seaman_china_standardization_2020.pdf. Accessed: 15 January 2021.

113 International Renewable Energy Agency (IRENA), «Green Hydrogen: A Guide To Policy-Making», Abu Dhabi: IRENA, November 2020, p. 9.

114 Abad, Anthony Velazquez, and Paul E. Dodds, «Green hydrogen characterisation initiatives: Definitions, standards, guarantees of origin, and challenges», *Energy Policy* 138 (2020): 111300.

115 Cited in: Sonja Van Renssen, «From blue to green: hydrogen's own energy transition», *Energy Monitor*, 14 August 2020. Accessed: 15 January 2021.

116 Axel Michaelowa and Sonja Butzengeiger, «Breakthrough of Hydrogen Technologies until 2030: Chances and Risks for Gulf Countries, International Policy Implications», in EDA Insights, September 2019. Available at: https://eda.ac.ae/docs/default-source/Publications/eda-insight_hydrogen-economy_en_final.pdf?sfvrsn=2. Accessed: 15 January 2021.

117 Ben Lefebvre, «French Government Blocks LNG Deal as too Dirty», *Politico*, 21 October 2020.

inantly denominated in US dollars. This gives the US strategic levers to exert power over other countries. For example, current US oil sanctions against Iranian oil exports are actually based on the monetary and financial hegemony of the US. Washington threatens to deny potential buyers of Iranian oil access to US financial markets and the US banking system[118]. India has tried to circumvent the sanctions regime by engaging in barter trade with Iran, while Europe has tried to set up an alternative payment mechanism, INSTEX, however to little avail. The EU is now keen to avoid such entanglement in the future. Its hydrogen strategy mentions the explicit goal of developing a benchmark for euro-denominated trade in hydrogen[119]. It would mean that, in this age of «weaponised interdependence», the US would have less leverage over EU hydrogen imports than it has over EU oil imports.

Conclusions

Without a doubt, hydrogen clearly has the potential to become a basic building block of a carbon-free world. As green hydrogen projects moves from megawatt to gigawatt-scale[120], it is clear that the political and business momentum is reaching new highs, and that hydrogen may finally come to live up to its promise as a clean energy carrier.

There are, however, big clashes of views with regard to the underpinning infrastructure and value chains of a future hydrogen economy (see Table 4). Concerning production, there is the clash between proponents of blue and green hydrogen. Obviously, the latter would be the most disruptive form of innovation, but the former still has the upper hand in terms of cost structure and compatibility with existing infrastructure. Concerning consumption, some want to use hydrogen across the board – from cars and trains to home heating and industry – leading up to a wholesale «hydrogen society» as Japan and Korea are aspiring

[118] Van de Graaf, T. (2013). The 'oil weapon' reversed? Sanctions against Iran and US-EU structural power. *Middle East Policy*, 20(3), 145-163.

[119] European Commission, «A hydrogen strategy for a climate-neutral Europe», Brussels, 8 July 2020, p. 21.

[120] Leigh Collins, «Gigawatt-scale: the world's 13 largest green-hydrogen projects», Recharge, 21 December 2020. Available at: https://www.rechargenews.com/transition/gigawatt-scale-the-worlds-13-largest-green-hydrogen-projects/2-1-933755. Accessed: 13 January 2021.

to become. Others, by contrast, just see hydrogen as an energy carrier that should be used in certain niches only – restricted to those few areas that cannot directly be electrified. Hydrogen, in the latter view, is often compared to champagne, an expensive luxury drink that you reserve only for special occasions, and which you certainly do not mix with water (i.e. hydrogen blending in existing natural gas pipelines).

	Blue hydrogen	**Green hydrogen**
Wide use	«Hydrogen society»	
Limited use		«Hydrogen as champagne of power fuels»

Table 4. Contrasting views on the future role of hydrogen

While the outcome of that battle is still uncertain, hydrogen will become a fixture of the new geo-economics of energy in the coming years and decades. The carbon-free fuel could be a geopolitical game changer for some countries. For countries like Chile and Morocco who lack fossil fuels and are forced to import large chunks of their energy supplies, the renewable energy transformation represents a complete reversal of fortune. If they succeed in becoming big exporters of green hydrogen, they could stand to gain in geostrategic importance, alongside other countries with abundant renewable potential such as Australia. However, they are unlikely to gain the same geopolitical weight as the current set of petrostates has had over the past few decades. Since hydrogen is mostly a conversion business rather than an extraction business, hydrogen export rents are likely to be smaller than fossil fuel rents. And since hydrogen can be produced basically anywhere in the world, hydrogen exporters will not have the same foreign policy leverage as, say, Russia or Saudi Arabia has based on their oil and gas exports.

Overall, though, hydrogen is unlikely to become the new oil, as popular belief holds. It is unlikely to ever reach oil's market share in the world's energy mix (currently more than 30% of primary energy), let alone match the liquidity and geostrategic significance of oil. Since hydrogen is a conversion business rather than an extraction business, rents will likely be smaller than those for oil, and they will be much more dispersed over a wider number of producers. If anything, hydrogen bears more resemblance to natural gas, and LNG in particular, and is more likely to lead to regional markets, especially in the mid-term.

That said, the geopolitical stakes surrounding hydrogen are vast. Even as a regionally traded commodity, hydrogen is one of those technologies that can reshuffle the geopolitical cards in the twenty-first century, alongside other technologies such as artificial intelligence, machine learning, electric vehicles, smart grids, and so on. Countries and companies are jockeying to control what is set to become a multi-billion dollar international commodity market. The size and scope of that market is still mired in uncertainty, but the clean hydrogen race is clearly on, and is deeply tainted with geopolitical incentives and implications.

Chapter four

Energy Geopolitics in the Maghreb. The Rise and Fall of Two Energy Superpowers. The cases of Algeria and Libya

Ignacio Fuente Cobo

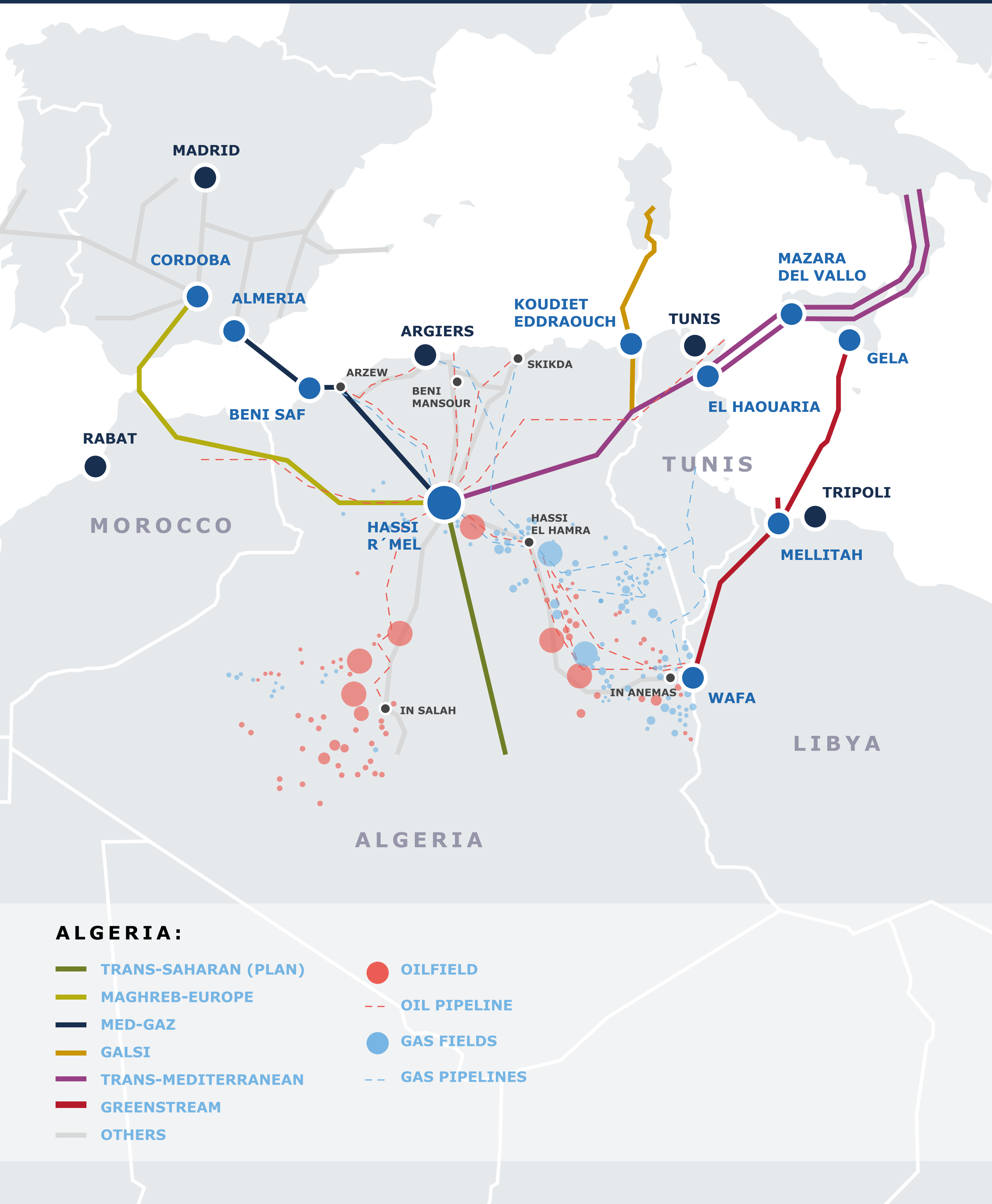
Abstract

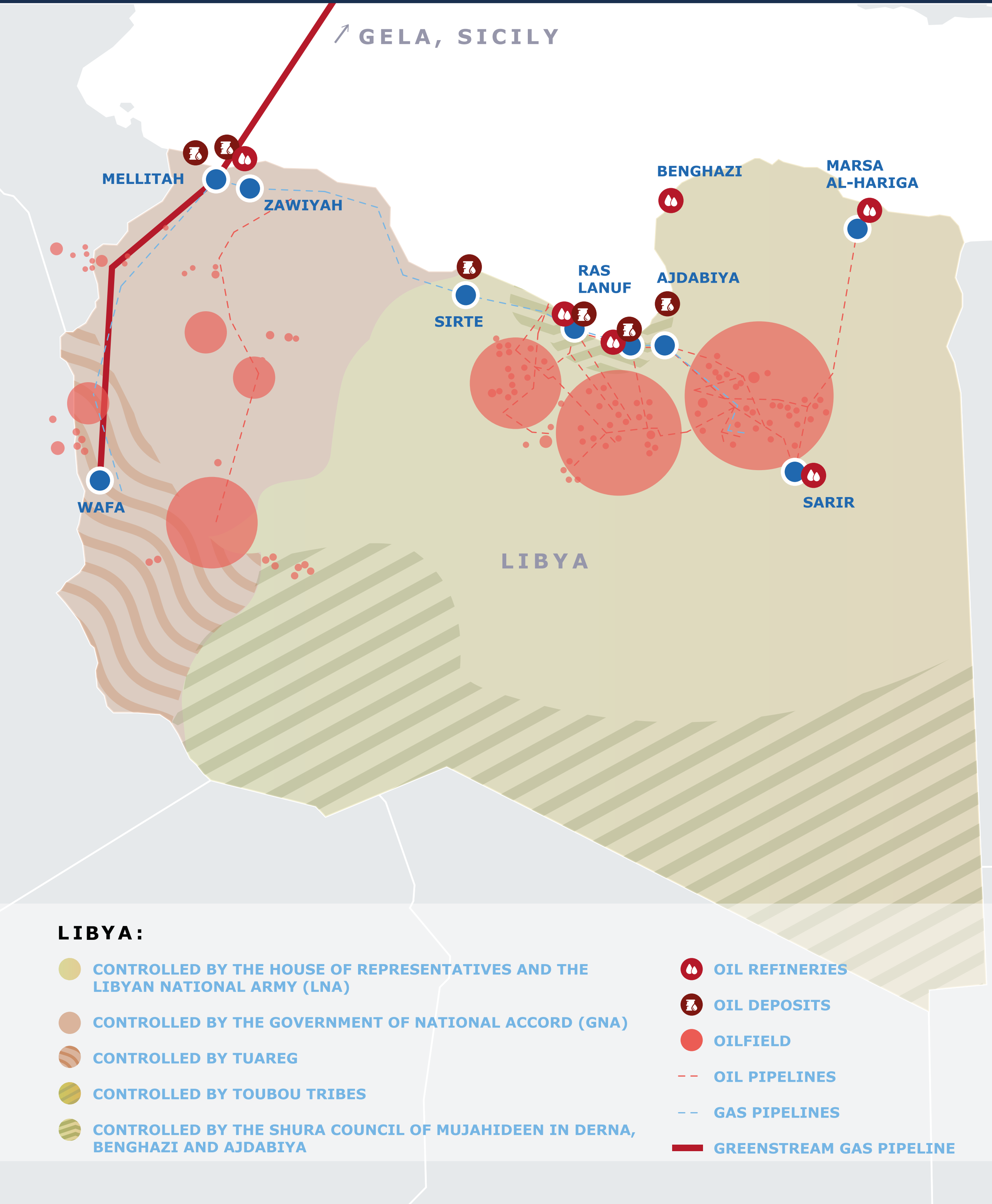
The Maghreb is a minor player on the global energy scene. The geopolitics of energy is conditioned by the existence of two hydrocarbon-rich powers, Algeria and Libya, which however do not have the capacity to develop a fully autonomous energy policy. Its performance in terms of oil and gas is in line with the behaviour of international markets and the requirements of other relevant actors, mainly from southern Europe, but also external to the region. Furthermore, in the current situation of the globalized energy market and with the disappearance of the regional hydrocarbon markets, their ability to act with national criteria has been severely restricted. The highly complex internal situation in both countries, although with their own characteristics in each of them, and the mono dependence of their economies on the rent of hydrocarbons for their own subsistence, complicates the panorama. Putting an end to the curse of resources, aggravated in the case of Libya because they are financing the war, and in Algeria because of the serious structural problems that its economy is facing, constitutes its great challenge in the coming years. The success of the reforms will depend on the active support of the international community and, in particular, of the European Union, whose interest in the Maghreb should increase, given the possibilities offered by these countries to provide low-cost energy to Europe, but also, and perhaps more importantly, given Europe's need to stabilize a vulnerable region with great potential to become a continuing source of security problems.

Keywords

Gas, Oil, gas pipelines, crisis, war, reforms.

ENERGY GEOPOLITICS IN ALGERIA AND LIBYA

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CONTROLLED BY THE GOVERNMENT OF NATIONAL ACCORD (GNA)
CONTROLLED BY TUAREG
CONTROLLED BY TOUBOU TRIBES
CONTROLLED BY THE SHURA COUNCIL OF MUJAHIDEEN IN DERNA, BENGHAZI AND AJDABIYA
OIL REFINERIES
OIL DEPOSITS
OILFIELD
OIL PIPELINES
GAS PIPELINES
GREENSTREAM GAS PIPELINE

Introduction

It is clear that the world energy order has undergone major changes in recent years. The global supply is currently characterised by a great abundance of hydrocarbon production, a considerable price reduction, and renewable energies that are increasingly making inroads in the global energy mix. All of this is modifying global energy geopolitics the world over, changing the balance of power and regional equilibria and affecting not only the producing countries but also the consumers. Few regions are being affected as much as northern Africa and few individual energy superpowers are being affected as much as Algeria and Libya; by changes that are having a major effect on those countries' current situation and their future prospects.

The first of these, Algeria, has sufficient resources to make it one of the richest countries in Africa and a prosperous country on an international level. Algeria is a geopolitical force in the Maghreb because of its population, its prestige, its geography and its revenue from hydrocarbons[1] and, theoretically, it could be an economic paradise. Algeria is fifteenth in the world ranking of proven oil reserves, with 12,200 million barrels[2], to which a further 150 billion cubic feet (Bcf) of natural gas must be added. The country also has extensive resources of undeveloped shale in seven basins that contain approximately 3,419 Tcf (trillion cubic feet) of potential gas, of which 707 Tcf are recoverable with current technology. Furthermore, six of these basins contain 121,000 million barrels of condensed shale oil, of which 5,700 million barrels are technically recoverable. All of this means that Algeria has the world's fourth largest reserves after the US, China and Argentina[3].

In 2019, hydrocarbon extraction had made Algeria the world's sixteenth greatest oil producer, the third biggest in Africa (after Nigeria and Angola) and eleventh in the world export ranking,

1 Mehdi Lazar, Sidi-Mohamed Nehad : »Vers une nouvelle Algérie?», Diploweb, La Revue Geopolitique, 08.12.2013. http://www.diploweb.com/Vers-une-nouvelle-Algerie.html.

2 Benoît Delmas, «La lettre du Maghreb – La Sonatrach, la boîte noire du pouvoir algérien», Le Point, 10 November 2019, https://www.lepoint.fr/afrique/la-lettre-du-maghreb-la-sonatrach-la-boite-noire-du-pouvoir-algerien-10-11-2019-2346292_3826.php.

3 «The ins and outs of shale gas», accessed 7 December 2020, https://atalayar.com/blog/los-entresijos-del-gas-de-esquisto.

as well as being the fifth largest producer and seventh largest exporter of natural gas on a global level[4].

Yet in spite of these huge resources, from Algerian Independence to the present time, the country has witnessed its hydrocarbons sector go through good times and periods of crisis that have brought about changes and ruptures to the institutional system that governs it, although its strategic nature having never been questioned. Today, Algeria´s oil and gas sector is in decline and is facing major structural problems, which will have to be overcome if the country wants hydrocarbons to remain the backbone of its economy and the basis for its economic development.

The case of Libya is quite similar. Libya has all the elements to become an energy superpower, because it has great comparative advantages over other regional or international competitors. Firstly, its proven oil reserves are considerable and could be estimated at over 48,000 million barrels (2016), approximately 2.9% of the world's total oil reserves; this is equivalent to 594.2 times its annual consumption, or a reserve-replacement ratio (RRR) of 153 years, which means that Libya has the greatest oil deposits in Africa[5]. The country's gas situation is similar, with reserves calculated at 1,549 trillion cubic metres (2014)[6].

Furthermore, most of Libyan territory is still to be prospected. So far, only the Sirte Basin has been extensively explored, whereas the Murzuq, Ghadames, Kufra and Cyrenaica Basins, as well as the Sirte Gulf in the open sea, have hardly been explored and have great potential, which makes them very appealing to the major international oil companies.

Secondly, Libyan oil is relatively easy to extract at prices that, in desert zones, could be as low as $2[7], making these resources extremely competitive on the international markets. Moreover, in the past, installing the infrastructure required for production and export has been a straightforward process, which has meant the

[4] «Libya Oil Reserves, Production and Consumption Statistics – Worldometer», https://www.worldometers.info/oil/libya-oil/.

[5] «Libya Oil Reserves, Production and Consumption Statistics - Worldometer», https://www.worldometers.info/oil/libya-oil/.

[6] «NATURAL GAS - PROVED RESERVES(CU M)», The World Factbook, Central Intelligence Agency, 2015, https://www.cia.gov/library/publications/the-world-factbook/fields/2253.html.

[7] «Why Libya's «sweet» crude oil is not enough to tempt BP or Shell | Oil | The Guardian», https://www.theguardian.com/business/2012/aug/26/libya-sweet-crude-oil-bp-shell.

oil-rich interior is connected to several different export terminals along the most densely populated coast, Libya's extensive network of oil pipelines, together with the absence of geographical obstructions to hinder exploration and development, pave the way for expanding production and attracting investment.

Thirdly, except for certain oil production in the open sea on the Pelagian Platform, Libya produces low-sulphur oil that is «sweet» and of excellent quality. The high quality of this oil and, thus, its direct listing on the top range of the complex oil market, means that the country's supply is greatly appreciated on the world's crude oil markets.

The fourth advantage is that Libya's oil lies close to the main consumption centres in Europe, which means the navigation times to the European ports, which consume most of Libya's oil exports, range from two days (Sardinia) to eleven days (Rotterdam), whereas it takes almost a month for oil to reach Asian destinations[8]; all of this means Europe is the obvious market for these resources. What is more, Libya has major natural gas reserves, especially in the Ghadames Basin, making the country a major exporter of gas to Europe through the Greenstream Pipeline that conveys it to Italy.

Therefore, it could be said that Algeria and Libya are the two major energy superpowers in northern Africa, and it is these two countries we will be focusing on in our geopolitical energy study of Maghreb, in view of the huge difference between hydrocarbon production and export levels when compared with the other countries in the region and given the major impact their evolution has on the international, European and Spanish markets.

Energy in Algeria. History of a mortgaged future

Characteristics of the Algerian Hydrocarbons Sector

Although it is not easy to obtain information that is reliable and verified, according to estimates made by Abdelmadjid Attar, Sonatrach's Ex-CEO and former minister, Algerian hydrocarbon resources can be divided into three categories[9]:

[8] «Libyan oil: Prospects for stability and growth», Apricot Energy Research, Vol. 03 No. 1, November 2018, https://www.apicorp.org/Research/EnergyReseach/2018/APICORP_Energy_Research_V03_N14_2018.pdf

[9] «Les exportations d'hydrocarbures pourraient baisser dès 2023»: Toute l'actualité sur liberte-algerie.com», https://www.liberte-algerie.com/actualite/les-exportations-dhydrocarbures-pourraient-baisser-des-2023-307849.

- Remaining proven conventional reserves (yet to be exploited), probable and possible: 9.8 billion barrels of liquid oil, 2.2 billion oil-equivalent barrels of liquefied petroleum gas (LPG) and 4.5 billion cubic metres of natural gas (4.5 BCM). Hassi R'Mel and Hassi Messaoud are the largest and most productive gas and oilfields in the country and account for 44% of the conventional reserves[10].
- Conventional resources yet to be discovered and technically recoverable: 1,400 million barrels of oil and 1,500 million cubic metres of natural gas.
- Technically recoverable unconventional resources: 6 to 8 billion barrels of oil and 22 billion cubic metres of natural gas.

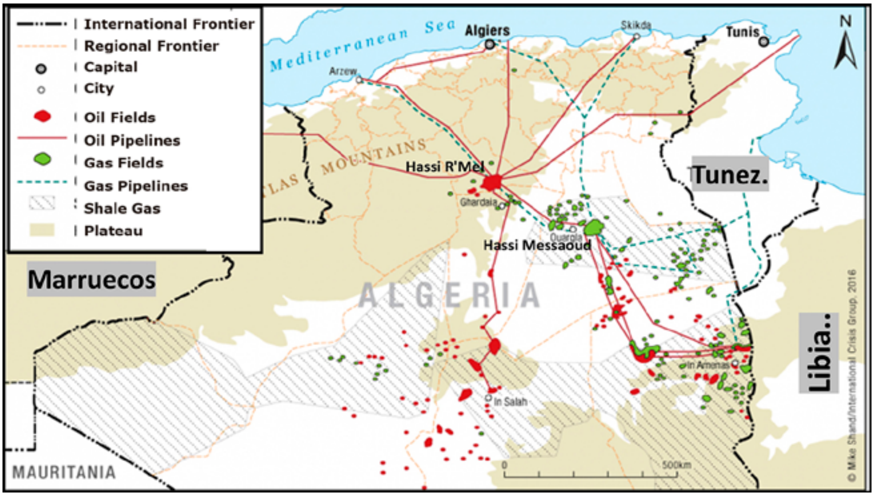

Figure 1. The gas and oil sector in Algeria. (Source: The Energy Consulting Group, http://energy-cg.com/OPEC/Algeria/Algeria_OilGas_Industry.html)

Europe is Algeria's main hydrocarbons export market, accounting for 70% of the total in 2017, followed by the USA (15%), Asia (9%), Africa (5%) and the Middle East (1%)[11]. 74% of the gas is exported via gas pipelines and 26% in the form of liquid natural gas (LNG)[12]. It is hardly surprising that Algeria once

[10] «The Report Algeria 2018», The Report Algeria 2018, Oxford Bussiness Group, s, 76. https://www.pwc.fr/fr/assets/files/pdf/2019/02/pwc-the-report-algeria-2018.pdf.

[11] «The Report Algeria 2018», 80.

[12] Mostefa Ouki, «Algerian Gas in Transition: Domestic Transformation and Changing Gas Export Potentia», Oxford Institute for Energy Studies, 2019, 15.

dreamt of becoming Europe's Maghrebi alternative to Russian hydrocarbons[13].

Algeria has an extensive gas pipeline network for conveying the resources to Europe: the Transmed, which connects Algeria to Italy (Mazara del Vallo) via Tunisia; the Galsi, which links Kudiet Draoucha with Italy (Sardinia); the Maghreb-Europe, which connects Algeria to Spain via Morocco and, finally, the Medgaz, which directly links Algeria to the Spanish coast.

Figure 2. Algerian and Libyan gas pipeline network (Source: http://efinternational.es/es/blog/la-nueva-Algeria/@@images/b2c98038-1ce4-4221-bb33-194a8be8ad31.png).

The two gas pipelines that connect Algeria with Spain via the Mediterranean play a strategic role: not only are they a main supply source for Spain and Portugal, but they also supplement each other and make it possible to replace Russian gas, whose access via the Pyrenees is blocked owing to France's lack of interest.

Since 1996, the Maghreb-Europe gas pipeline (GME), also called the Pere Duran-Farell gas pipeline (GPDF), with a capacity of 12,000 million cubic metres per year, links the Hassi R'Mel natural gas deposits (in the Algerian Sahara) with Spain, running through Morocco and the Strait of Gibraltar. It is 1,430 kilometres

13 «Moroccan-Nigerian Pipeline Puts Final Nail in Algeria's Trans-Saharan Gas Project | The North Africa Post», https://northafricapost.com/17999-moroccan-nigerian-pipeline-puts-final-nail-algerias-trans-saharan-gas-project.html.

long (575 km through Algeria, 540 km in Morocco, 45 km under the Mediterranean and 270 km to Cordoba); the natural gas takes about five days to reach its destination[14]. The Algerian section of the gas pipeline is owned and operated by the Algerian energy company Sonatrach. The Moroccan section is owned by the Moroccan State and operated by Metragaz, a Joint Venture formed by Sagane (a subsidiary of the Spanish firm Gas Natural), Transgas (Portugal) and SNPP (Morocco). The section that crosses the Straits of Gibraltar is 45 kilometres long and belongs to the company Gasoducto Europa-Maghreb (EMPL), in which Grupo Gas Natural has a shareholding, plus the Portuguese firm Transgas and the Moroccan company SNPP[15].

The other gas pipeline is the Medgaz, from Oran to Almeria, with a capacity for conveying 8,000 million cubic metres per year. Opened in 2011, Medgaz Algeria enables gas to be transported to Spain directly, instead of depending exclusively on the Maghreb-Europe gas pipeline via Morocco. In April 2020, the Spanish company Naturgy purchased 34% of Medgaz from Mubadala for around €445 million, so the gas pipeline is now owned exclusively by the energy company Naturgy, having a 49% shareholding, and the Algerian Sonatrach holding the remaining 51%[16].

The Natural Resources' Curse

With so many energy resources, the question we have to ask ourselves is… If Algeria is so rich, why are the Algerians still poor? The answer lies in the lack of a sufficiently well-structured economic diversification, which has meant that the revenue obtained from oil and gas exploitation has been the main and almost only source of income for the Algerian Government ever since Independence in 1963. At present, hydrocarbons account for about 35% of the gross domestic product and two-thirds of all exports[17].

[14] Mónica Salomone, «Spain opens the Gibraltar Gas Highway», El Pais, 4 December 1996.

[15] «Work begins on the extension to the Maghreb-Europe Gas Pipeline: Geoscope», accessed on 4 December 2020, http://www.geoscopio.com/guias/ene/noticias/Se_inicia_la_ampliacion_del_gas pipeline_MaghrebEurope_7501.htm.

[16] «Naturgy and Sonatrach, the owners of the Algeria-Spain gas pipelines – El Periodico de la Energía | El Periodico de la Energía with daily information about electricity, wind energy, renewable energy, oil and gas, markets and energy legislation», https://elperiodicodelaenergia.com.

[17] «The oil and gas industry in Algeria: an overview | Trace Software Spain», accessed on 7th December 2020, https://www.trace-software.com/es/industria-del-petroleo-y-gas-en-Algeria-una-vision-general/.

Further answering the question asked above, it would also be necessary to add the fact that for decades there has been a lack of productive reinvestment of the large amounts of revenue generated by oil; this has led to a situation where 95% of consumer goods have had to be imported, including petroleum by-products[18]. Despite being a major oil producer, Algeria is in the paradoxical position of being rich in hydrocarbons, but lacking in refined products, which means that it is a net importer of fuel. The country's six refineries cannot meet the demand, so considerable quantities of fuel have to be imported, especially diesel oil and petrol, which account for nearly 80% of energy by-product imports[19].

Algeria's good fortune in having abundant energy has its negative side, because it prevented the country from diversifying economically, to the extent that it has come to epitomise the «natural resources´ curse». Also referred to as the «Dutch disease syndrome», this means a rising currency value brought about by a sharp increase in hydrocarbon exports, encouraging imports and discouraging exports and, so, disincentivising diversification of the country's economy.

At the same time, it drives away capital and the manufacturing and agricultural work force, increasing the cost of production in those sectors, making them less competitive[20]. The consequence of the Algerian economy's overdependence on hydrocarbons is its greater exposure to the risk of significantly reducing industrial activities outside the mineral sector, because they are less profitable and thus less likely[21].

All of this leads to an economy affected by the volatility of hydrocarbon prices on the international markets, which has consequences, on the country's internal situation that are often dramatic. In this regard, Algeria puts across a «schizophrenic» image of a country totally dependent on oil revenue that fails to

18 Lakhdar Habib, « Une future puissance régionale ? », L´Est, 19 April 2014. http://www.lestrepublicain.com/index.php?option=com_k2&view=item&id=10440:une-future-puissance-r%C3%A9gionale-?&Itemid=585.

19 «The Report Algeria 2018», 87.

20 Papyrakis, Elissaios / Raveh, Ohad (2014): «An Empirical Analysis of a Regional Dutch Disease: The Case of Canada», Environmental and Resource Economics 58, no. 2, 179–98.

21 Palma, José Gabriel (2014): «De-Industrialisation, «premature» de-industrialisation and the Dutch Disease», Revista NECAT-Revista Do Núcleo de Estudos de Economia Catarinense 3, no. 5, 7–23. pp.8.

offer its inhabitants the possibility of promotion, especially those in the youngest bracket, who turn to illegal immigration as an alternative.

The result is that, unlike Morocco and even Tunisia, whose economies are much more diversified, Algeria has a «rentier» economic model where public resources are almost entirely allocated to subsiding basic needs and to financing operating expenses, in a country where the State and its subsidiary firms provide half the jobs[22].

Therefore, this situation gives the impression of an Algerian economy that operates with its hand on the brake, which means an economy subjected to the worst effects of its contradictions: dismissals, unemployment, salary reductions and greater inequalities.

An economy historically dependent on hydrocarbon prices

At the same time, Algeria's total dependence on oil and gas has given rise to an economic model that has always been affected by the volatility of hydrocarbon prices on the international markets, with consequences that have sometimes been dramatic, in the country's own domestic situation. One such example occurred during the 1986 Oil Crisis, when the State's foreign debt and the drop in oil sales forced Algeria to adopt a stringent structural adjustment plan (1994-98) under the supervision of the International Monetary Fund and the World Bank.[23]

The oil kickback can be regarded as a key moment in the deterioration of Algeria's economic decline[24]. It had a great effect on society as a whole and led to what came to be known as the Berber Spring of 1988, the subsequent emergence of terrorist groups, mainly the Armed Islamic Group (GIA), a forerunner of Al-Qaeda in the Islamic Maghreb (AQIM), the coup d'état in 1992 and the «Black Decade», which lasted from 1991 to 2000, when

[22] Algerians enjoy energy subsidies (petrol cost 25 centimes a litre in March 2020), free universities, access to public health, even free books and homes for those who live more than 50 km away.

[23] Mustapha Mekideche, »Le secteur des hydrocarbures en Algérie. Piège structurel ou opportunité encore ouverte pour une croissance durable?», Dans Confluences Méditerranée 2009/4 (N°71), 153-166.

[24] Thomas Serres, «L'Algérie face à la catastrophe suspendue: gérer la crise et blâmer le peuple sous Bouteflika (1999-2014)», KARTHALA Editions, 2019, 30.

over 200,000 Algerian citizens lost their lives during the course of a savage civil war[25].

The economic indicators only began to stabilise after 2000, encouraged by an increase in hydrocarbon prices, together with President Buteflika's launching of the «Economic Revival Support Plan» in April 2001 during his first term of office, which enabled the country to increase its budget revenue from 950.5 million dinars in 1999 to 5,957.5 in 2013.

During this boom period lasting until 2014, Algeria felt the benefits of certain very favourable international market conditions. Between 2005 and 2008, natural gas production rose from 146.2 to 171.1 billion m^3, whereas crude oil production increased from 51.1 to 57.9 million tonnes. All of this enabled the revenue from oil and gas to increase by 6.2 (+526%) in a 15-year period[26], so that by 2008 Algeria's financial base was $51,000 million, equivalent to 24 months of imports[27].

At the same time, and based on the experience of the 1980s, in 2000 the Algerian Authorities set up the «Revenue Regulation Fund» (FFR), a sovereign wealth fund supplied by a fraction of the budget surplus from hydrocarbon exports, whose aim was to keep the Algerian economy stable in the face of sharp falls in hydrocarbon prices on the international markets. In a favourable energy context, in 2014 the FFR reached the maximum level of 193 billion dollars, after which it began to decrease.

By midway through the first decade of this 21st Century, Algeria appeared to have learnt the lesson of the 1980s and that its years of extreme poverty were over. A favourable international context together with an improvement in the country's internal security, with the destruction of most of the terrorist cells operating inside the country and the ousting of the Armed Islamic Group to a zone in the Sahel where, after 2007, they were to become an offshoot of Al-Qaeda, allowed Buteflika's first two governments (1999-2004 and 2004-2009) to legislate with a view to attracting new investors in this key sector of the economy. At the time, it

25 Pierre Daum, «Mémoire interdite en Algérie, Le Monde diplomatique, August 2017», https://www.monde-diplomatique.fr/2017/08/DAUM/57773.

26 Amayas Zmirli, «Algérie - Plans de relance: la chronique d'un échec annoncé? - Le Point», https://www.lepoint.fr/economie/algerie-plans-de-relance-la-chronique-d-un-echec-annonce-09-10-2017-2162999_28.php#.

27 Kassim Bouhou, «L'Algérie des réformes économiques: un goût d'inachevé», *Politique étrangère* Eté, no. 2 (2009): 323, https://doi.org/10.3917/pe.092.0323.

seemed that Algeria was in a position to open up its hydrocarbons sector to the competition.

However, the structural reforms requested by the IMF to transform Algeria into a market economy were not implemented. The increase in oil and gas prices, coupled with the investment and public expenditure cutbacks, enabled the regime to gain time and put off major reforms designed to diversify the economy so that it would not have to rely on hydrocarbons and change its growth model. Algeria lost a historic opportunity to modernise its economy[28].

The Hydrocarbons Act was passed in 2005. It reduced the duration of contractual negotiations and offered a taxation system that sought to strengthen alliances with foreign firms and increase the number of operators in the sector, in such a way that the number of discoveries could be increased. However, this Act was fiercely opposed by the Regime's most conservative elements, who claimed that energy resources were being handed over to foreign companies[29], and it was these groups that eventually won the day. In 2006, an amendment was passed requiring Sonatrach to hold a 51% share in every contract signed with foreign operators, which made it less attractive for foreign capital to get involved in developing the country[30] rendering it about as appealing as a forced marriage»[31].

Consequences of the structural limitations of the Algerian economy

The structural limitations of the Algerian economy were brought to light as from 2014 with the drop in the prices of Brent and Sahara Blend hydrocarbons (this last being the one that the country exports), when the current account balance fell from a surplus of 10% in 2010, to a deficit of -3.3%, in 2014[32]. Similarly,

[28] «Algeria: Toward an economic collapse? | Middle East Institute», https://www.mei.edu/publications/algeria-toward-economic-collapse.

[29] Maâmar Benguerba, «L'Algérie en péril: gouvernance, hydrocarbures et devenir du Sud», Editions L'Harmattan, 2006, 121-30.

[30] Bouhou, «L'Algérie des réformes économiques». Op.cit.

[31] Yves Bourdillon, «Le «modèle» économique algérien à bout de souffle», Les Echos, 5 December 2017, https://www.lesechos.fr/2017/12/le-modele-economique-algerien-a-bout-de-souffle-188692.

[32] World Bank, «Global Economic Prospect 2015», January 2015, https://www.worldbank.org/content/dam/Worldbank/GEP/GEP2015a/pdfs/GEP15a_web_full.pdf.

gas and oil exports fell by 9% in quantity and 42% in value, in the period between the first 6-month periods in 2014 and 2015 (i.e., they decreased from $33,210 to $19,280 million).

This fall caused a reduction in oil production, which dropped from two million barrels per day to 1.5 million between 2005 and 2014, while gas production decreased by approximately 11%, falling from 88 billion cubic metres (Bcm) to 78 Bcm in the same period, stagnating at 83 Bcm for the next two years. However, in 2017 production recovered and a notable increase of 14% was recorded when compared to 2015, partly due to the Tiguentourine gas processing facilities (In Amenas), which had been damaged during an Al-Qaeda terrorist attack in January 2013, returning to full capacity, plus the fact that there were slight increases in the In Salah gas supplies[33].

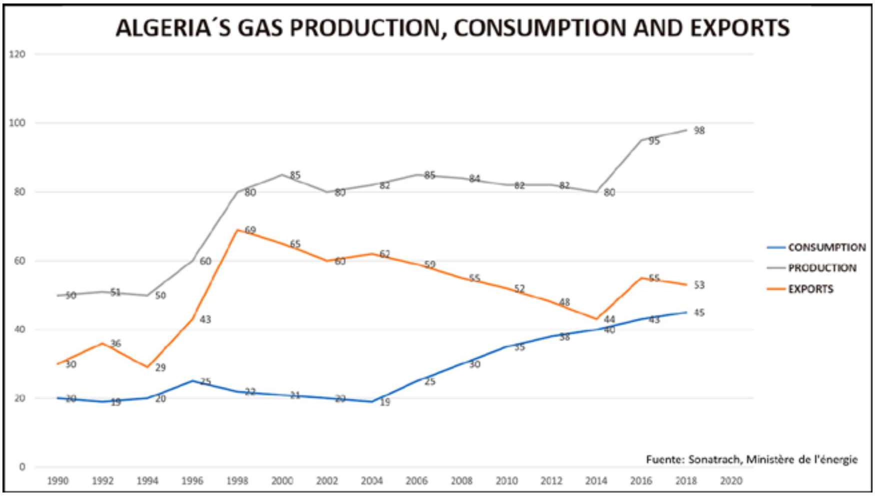

Figure 3. Algeria´s gas production, consumption and export (Source: Sonatrach Ministère de l´énergie).

The fact that production evolved negatively since 2008 can basically be attributed to four factors[34]: the aging of the main production fields, a low renewal rate for new and proven reserves (discoveries), stagnation of the technical recovery rate that is

[33] Mostefa Ouki, «Algerian Gas in Transition», OIES PAPER: NG 151, The Oxforf Institute for Energy Studies, 2019, p.3, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/10/Algerian-Gas-in-Transition-NG-151.pdf.

[34] «Les exportations d'hydrocarbures pourraient baisser dès 2023»: Toute l'actualité sur liberte-algerie.com».

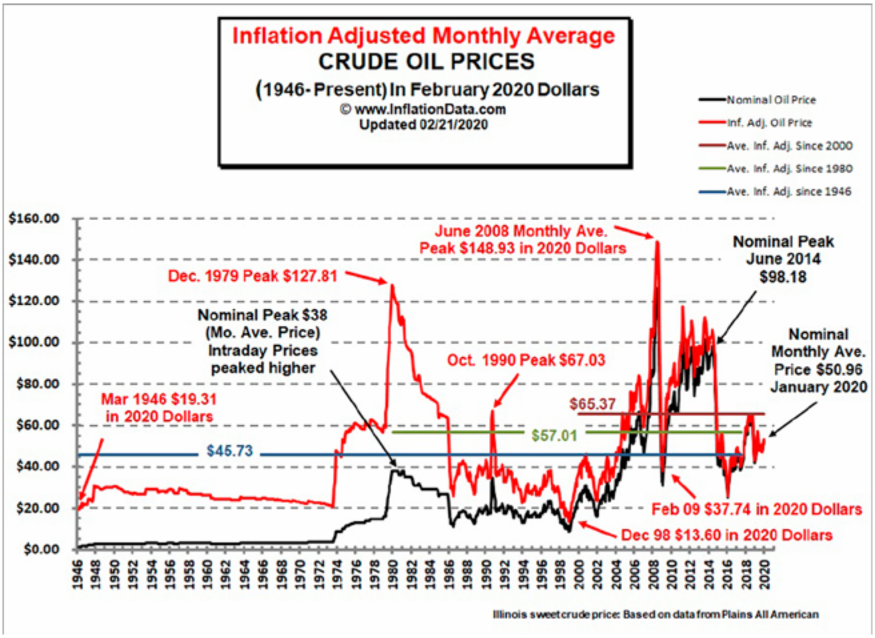

Figure 4. Crude Oil Prices 1946 - Present.
Fuente: https://inflationdata.com/articles/inflation-adjusted-prices/historical-oil-prices-chart/.

still too low when compared to what could be achieved with new investments, and, finally, an inability to put recent discoveries into production. Thus, at the 2017 production rate, gas reserves are expected to run out in 47.5 years and oil reserves are expected to do likewise in 21.7 years[35].

Furthermore, Algeria was unsuccessful with new tenders (four licences granted out of the 31 bid for in September 2014) which, combined with the reluctance of many companies to operate in the country, ruined Sonatrach's ambitious exploration project (2014-2019), the State-owned hydrocarbons company, which had anticipated an investment of $102,000 million[36]. In the following years, all of this led to the abandonment of several projects that would have had considerable socioeconomic impact – including the construction of public hospitals and other projects providing employment – in a climate of constant depreciation of

35 «The Report Algeria 2018», 79.

36 Francis Ghilés: «Algeria: the transition to the uncertain», EsGlobal 29 December 2015.

the dinar and price increases affecting both local consumer products and imported goods, as well as semi-finished products and commodities.

All of this reveals the Algerian economy's major structural limitations owing to a lack of diversification, the absence of a comprehensive investment plan and a lack of rigour where financial regulation is concerned. The consequence of the uselessness of the local production mechanisms was the Revenue Regulation Funds» (FFR) exchange reserves being utilised systematically, to cover the budget deficits in the ensuing years.

The positive aspect was that oil and gas exports, albeit diminished, could be supplemented by using the FFR, which enabled the country to keep the foreign deficit at -2.3% in 2013, increasing to -4.7% in 2018[37] and keeping the unemployment rate down to 9.7% in 2014[38], this percentage having increased slightly to 11.7% in 2019[39].

The fact that there is no foreign debt shows that the Algerian State still has a degree of financial margin, which means that in the near future it is rather unlikely that there will be a default scenario in the short term that would lead to a drop in the value of the local currency. Yet Algeria could still find itself suddenly required to allow its currency to depreciate and have to resort to external debt[40].

The use of an unconventional internal financing for the budget debt thus indicates the failure of all the economic development plans devised by President Buteflika's different Governments in the first decade of the new Millennium, since these plans, instead of liberalising the Algerian economy, silenced it. So, the Report for the year 2019 issued by the Fraser Institute, ranks Algeria as one of the five least «economically free» countries in the Arab World, a long way behind Morocco or Tunisia[41].

37 Expansión/Datosmacro.com. https://datosmacro.expansion.com/deficit.

38 «Taux de chômage par pays». Statistiques mondiales.com. http://www.statistiques-mondiales.com/chomage.htm.

39 https://es.theglobaleconomy.com/Algeria/unemployment_rate/.

40 See Report on the Middle East and North Africa from Crisis Group N°214, «Pulling Lebanon out of the Pit», 8 June 2020.

41 Salem Ben Nasser Al-Ismaily, Azzan Al-Busaidi, Miguel Cervantes, Fred McMahon, «Economic Freedom of the Arab World: 2019 Annual Report», 18 December 2019.

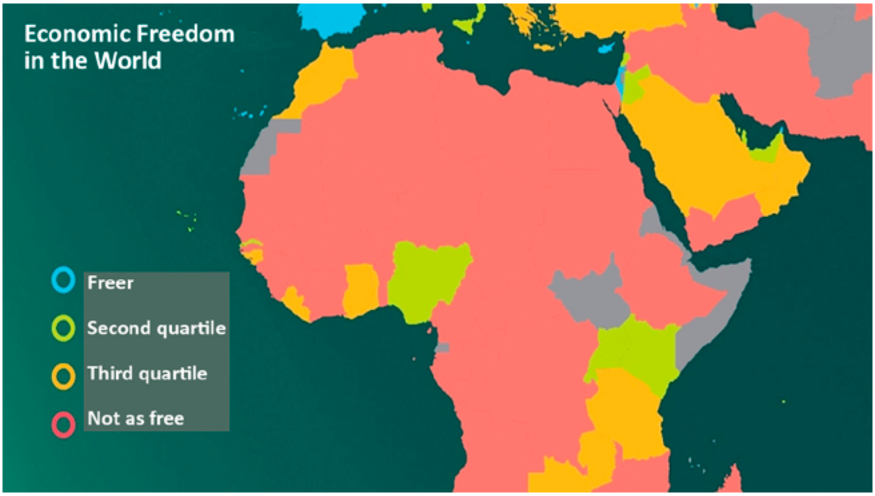

Figure 5. Economic Freedom in the World. (Source: https://www.infobae.com/america/mundo/2018/09/25/el-ranking-de-la-libertad-economica-global-chile-lidera-en-la-region-y-venezuela-se-afianza-en-el-ultimo-puesto/).

The rupture of the social contract

The fall in the price of crude oil from 2014, with its impact on the lives of Algerian citizens, left those in power without the vital factor for controlling the population. It must be remembered that during the Buteflika Era – when oil reached 148.93 dollars/barrel in June 2008 (with the average monthly price adjusted to inflation) – the country benefited from a billion dollars in oil revenue that was entirely allocated to buying social peace[42]. But by 2014, this era of abundance, which required a minimum price of 110 dollars on the international markets, had come to an end.

When hydrocarbon prices began to drop, the foreign trade deficit in a country that imports almost everything, rapidly deteriorated and reached $70,000 million. The social contract frittered away the reserve fund «just like ice in the sun», and reserves fell from 200 billion dollars in 2014 to a mere 62 billion by the end of February 2020, just before the COVID-19 pandemic struck, and it is predicted that if it continues to dissipate at the current rate,

42 Yves Bourdillon, »Le «modèle» économique algérien à bout de souffle», Les Echos, 5 December 2017, https://www.lesechos.fr/2017/12/le-modele-economique-algerien-a-bout-de-souffle-188692.

there will be nothing left of the Revenue Regulation Fund (FRR) before 2022[43].

The progressive deterioration of the economic situation led to the emergence of a horizontally organised citizens' protest movement called Hirak (Movement) in February 2019, which in contrast to the Islamic or Amazigh movements, defended a perspective of citizenship that went well beyond the political and socio-regional divisions that had caused so many violent struggles in the past[44].

On 2 April 2019, the Military Chief of Staff and Deputy Minister of Defence, Ahmed Gaïd Salah, under pressure from the mobilisation of millions of citizens throughout the country[45], forced President Abdelaziz Buteflika to resign. He had been in power since 1999 and had announced his intention to stand again for a fifth term of office, despite his age – 78 years – and his delicate state of health[46].

On 12 December 2019, Abdelmadjid Tebboune, the former Prime Minister, was elected as President of the Algerian Republic, in elections characterised by low voting and street protests. Although the new President applied a policy of appeasement[47], some Hirak activists stressed the need to carry on with the protests in the face of what they regarded as the newly elected President's strategy having ignored the people´s demands. However, in March 2020, an overwhelming majority of the protestors decided to temporarily shelve their demands in the face of the new global pandemic, and to stop street demonstrations. It was a question of «giving Hirak a break so it could return with renewed strength» [48] when the circumstances were more favourable.

At the same time, and in order to limit the economic and social effects of the pandemic, as from March 2020 the Government

43 Hassan Haddouche, «L'Algérie pourra-t-elle échapper au FMI?», Middle East Eye, 6th August 2020, https://www.middleeasteye.net/fr/opinion-fr/algerie-petrole-fmi-crise-economique. World Bank, «Global Economic Prospect 2015», January 2015,

44 «Socialités et humanités. La citoyenneté en movement», Revue des sciences sociales, no. 7 (2019).

45 «Algérie : vers le déconfinement du Hirak ?», Crisis Group, 27 July 2020, https://www.crisisgroup.org/fr/middle-east-north-africa/north-africa/algeria/217-algerie-vers-le-deconfinement-du-Hirak.

46 »Le président algérien victime d'un AVC», AFP, 28 April 2013. http://www.lalibre.be/actu/international/le-president-algerien-victime-d-un-avc-51b8fc43e4b0de6db9ca6630-.

47 Zeinab Filali, «Algérie : le président Tebboune met fin à une expression aussi vieille que l'indépendance»,, Financial Afrik, 23 April 2020.

48 «Algérie».

took a series of proactive decisions. These decisions ranged from postponing the payment of income tax and value added tax (VAT) for two months, to closing non-essential public services, and granting half of the executives and agents in the sector an exceptional paid leave for 14 days renewable.

Other back-up measures were also adopted for firms and the most deprived sectors of the population, such as the payment of a 10,000 dinar (€72) subsidy to families in need, plus the suspension of penalties for delays in works performed and services provided in public contracts[49]. To prevent panic buying due to food shortages, since the end of March the Authorities have been guaranteeing the country's food supplies and have sought to calm down the population by increasing wheat orders on the international markets and increasing semolina production[50].

The fall in prices, which also affected the gas sale contracts, mainly indexed to oil, threatened to deplete the decimated currency reserves while at the same time increasing the fiscal deficit. The outcome was a critical situation affecting the Algerian economy for which the IMF forecast a 5.2% drop in 2020[51] and a fiscal deficit of 20% of the GDP[52]. In the context of a decrease in oil prices and a severe economic crisis aggravated by the COVID-19 pandemic, in May 2020, the new President promised to keep the country independent, rejecting the possibility of «resorting to loans from the IMF or the World Bank»[53]. It was an attempt to avoid repeating the negative experience the country suffered at the beginning of the 1990s, when it obtained IMF loans.

His proposal, with strong hints of nationalism, has been to resort to the savings of Algerian citizens that operate in the informal sector outside the traditional financial system and that amounts to between €42,570 and €71,000 million, because «when we ask

[49] «Une allocation de 10 000 DA aux familles impactées par la crise sanitaire», Tout sur l'Algérie, 13 April 2020.
[50] «L'Algérie multiplie les achats de blé sur les marchés internationaux», El Iqtisadiya, 3 April 2020.
[51] «Confronting the Covid-19 Pandemic in the Middle East and Central Asia», FMI, Abril 2020.
[52] Heba Saleh. Op.cit.
[53] «I would rather borrow from Algerians than from the IMF says President», Corona Chronicles: 4 May – 7 May, Jeune Afrique with AFP, 20th May 2020. https://www.theafricareport.com/27332/i-would-rather-borrow-from-algerians-than-from-the-imf-says-president/.

for loans from foreign banks, we cannot mention Palestine or the «Western Sahara»[54], two causes that are very dear to Algiers.

However, if the reserves do run out, which is a plausible hypothesis for 2023 and if a minimum degree of food and social security is not guaranteed, the Algerian Government may have no alternative but to resort to the International Monetary Fund and the World Bank if it wishes to prevent social upheaval[55], especially if we take into account the fact that Algeria is a country in which approximately 50,000 small businesses are at risk of going bankrupt because of the measures aimed at containing COVID-19[56] and where more than 10 million informal workers (45% of the work force), have seen how their income has been significantly reduced during the partial lockdown period[57].

The disclosure at the end of March 2020 that the Government was having talks with the IMF to guarantee part of a package of global rescue measures amounting to 50,000 million dollars is a good indication of the scale of the crisis, in view of the fact that the fund with its headquarters in Washington has a very bad reputation in Algeria[58].

However, the fact that the State budget is not overwhelmed by an unsustainable foreign debt is comforting and shows that the State has a degree of room to manoeuvre from a financial perspective. Yet this does not necessarily mean that Algeria might not suddenly find itself plunged into a situation where it has to allow its currency to depreciate and has to resort to external debt[59].

All in all, «Algeria has sufficient buffers to adapt to the crisis in the short term. Even so, the harder the crisis hits in the rest of the world, the greater the risks will be to the Algerian economy and its ability to accept the new reality of lower oil prices, difficult external financing conditions and a constant depletion of its international reserves»[60].

54 Ibidem.

55 Ali Benouari, « Crise économique: rompre impérativement avec les méthodes de gestion du passé », Le Soir d'Algérie, 16 April 2020.

56 «Plus de 50 000 restaurants et cafés au bord de la faillite», *El Watan*, 7 July 2020.

57 «L'emploi informel en Algérie : tendances et caractéristiques (2001-2010)», Les cahiers du MECAS, no. 12, June 2016.

58 «Algeria's upstream rebirth is interrupted», https://www.petroleum-economist.com/articles/upstream/exploration-production/2020/algeria-s-upstream-rebirth-is-interrupted.

59 «Pulling Lebanon out of the Pit | Crisis Group», https://www.crisisgroup.org/middle-east-north-africa/eastern-mediterranean/lebanon/214-pulling-lebanon-out-pit.

60 «Algeria: Toward an economic collapse? | Middle East Institute».

The Algerian energy sector crisis

Since 2014, the Algerian energy sector has been in crisis. The sharp drop in oil prices that happened that year brought about a 9% drop in gas and oil export figures, amounting to a 42% drop in their value, in the period between the first six months of 2014 and 2015 (i.e., they fell from $33,210 million to $19,280 million).

Although the situation improved slightly in the following years, the coronavirus crisis has had a major impact on a sector fraught with a serious structural crisis. Algeria was one of the countries most affected by Saudi Arabia's decision, at the beginning of March 2020, to embark on a price war, a measure that aggravated the collapse in demand caused by COVID-19, causing the Brent and Sahara Blend oil prices to fall from 70 and 65 dollars a barrel, in January 2020, to respectively 19 and 15 dollars in April 2020.

Although prices rose once again in June, both qualities reaching 42 dollars, they are still highly volatile and depend on the extension to the reduction in supply that the Organization of the Petroleum Exporting Countries (OPEP +)[61] decided to implement. As the Minister of Energy, Abdelmadjid Attar, has stated, «Algeria is suffering economically. The international oil market has collapsed. Hydrocarbon production has plummeted, Oil exports have plummeted. Algeria's oil revenue is having serious problems»[62].

Notwithstanding, it is not only a question of hydrocarbon prices falling, but also that in Algeria, as is the case in other African oil-exporting countries, population growth and an increase in urban development, are bringing about a greater domestic demand for energy, which has increased by over 50% since 2007, whereas oil production has fallen by 25%[63].

The unwillingness of the Algerian Authorities to tackle the politically thorny question of subsidies, in a country where – in gas and electricity alone – subsidies amount to around $8,000 mil-

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[61] «L'OPEP+ poursuit sa stratégie de baisse de l'offre pétrolière», Connaissance des énergies, 8 June 2020.

[62] Khaled Remouche, «Rente, situation économique, réserves et transition énergétique: Attar au personnel de Sonelgaz, le compteur à l'heure de crise !», Reporters, 16 July 2020. https://www.reporters.dz/rente-situation-economique-reserves-et-transition-energetique-attar-au-personnel-de-sonelgaz-le-compteur-a-lheure-de-crise/

[63] «Algeria, che cosa farà Sonatrach con ExxonMobil, Chevron, Eni e Lukoil - Startmag», https://www.startmag.it/energia/perche-lalgeria-non-si-gasa-piu-con-il-suo-gas/.

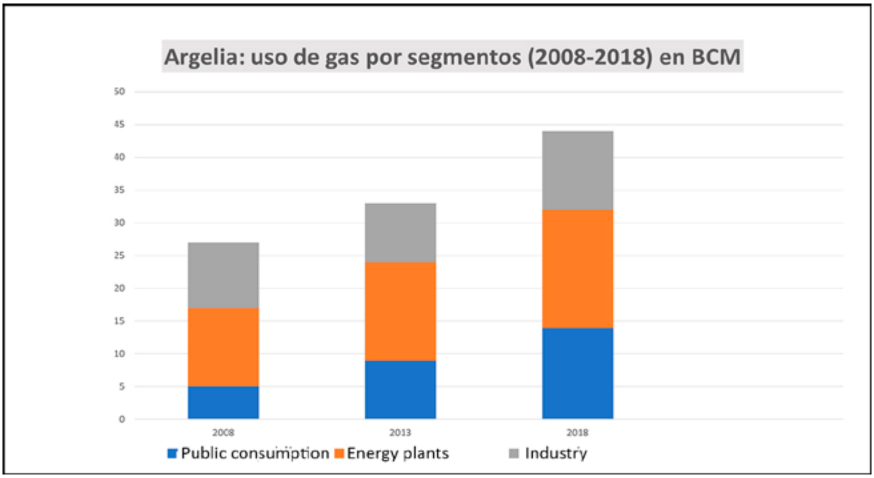

Figure 6. Use of gas by sectors. (Source: Fraser Institute 2019).

lion, or what amounts to the same, 4% of the GDP, does not help to improve this already difficult situation. What is more, low electricity prices for Algerian consumers (approximately 30% of its production cost) is one of the main factors that has led to the rapid increase in domestic consumption and the hazardous reduction in the export of hydrocarbons, which are becoming increasingly consumed locally[64]. All of this has contributed towards jeopardising export capacity with the consequent negative effect on the foreign balance of payments.

This particularly difficult state of affairs regarding Algerian hydrocarbon exports has been further accentuated by the loss of market share in major markets such as Spain, where in 2020, for the first time in 30 years, Algeria ceased to be Spain's top supplier, having been ousted by the US. In February 2020, US natural gas accounted for 27% of Spanish imports, whereas Algerian supplies only amounted to 22.6% of total natural gas imports, with a very sharp drop of up to 38.4% when compared to the same period in 2019 when the percentage stood at 48.5%[65].

All of the above has served to hasten the country's economic decline, causing revenue from oil and gas exports to amount to a mere 23,000 million dollars in 2020, a reduction of $10,000 mil-

64 «L'augmentation des prix de l'électricité est l'affaire de l'État»: Toute l'actualité sur liberte-algerie.com», accessed 10th September 2020, https://www.liberte-algerie.com/actualite/laugmentation-des-prix-de-lelectricite-est-laffaire-de-letat-306654.

65 «L'Algérie perd sa place de fournisseur principal en gaz de l'Espagne», https://www.dzairdaily.com/algerie-premier-fournisseur-gaz-espagne-hydrocarbures/.

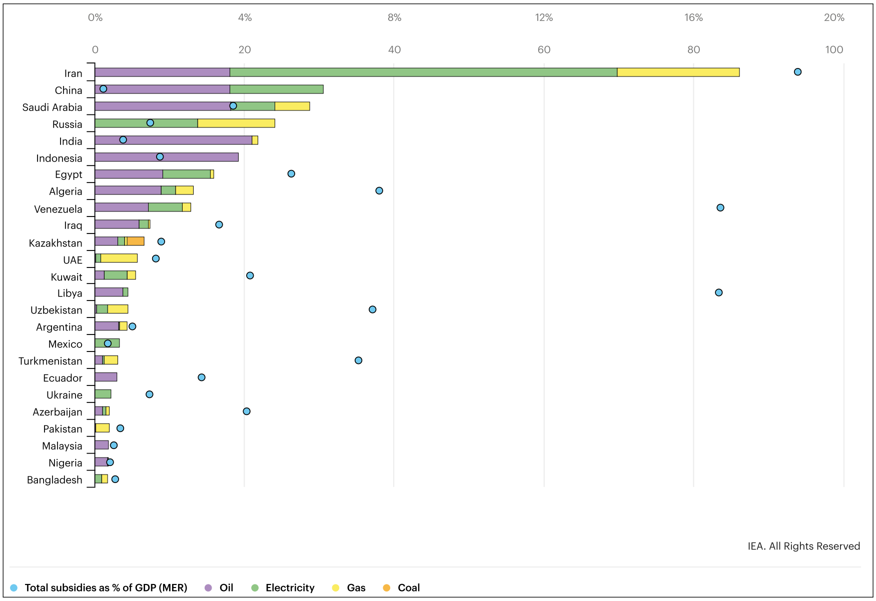

Figure 7. Fossil fuel subsidies.
Source: AIE, https://www.iea.org/topics/energy-subsidies.

lion in comparison with the year before[66] and 18,000 million when compared to 2018[67]. Even with the highly competitive cost of oil in some of its deposits, such as those in Hassi Messaoud – where the price can be even lower than $3 per barrel – Algeria needs a minimum price of 100 dollars per barrel to balance its budget[68].

The problems affecting the State-owned energy companies

Algeria has two large energy supply and distribution companies, Sonelgaz and Sonatrach. The former, the *Sociètè Nationale de l'Electricité et du Gaz*, (Sonelgaz) is the public firm responsible for distributing electricity and natural gas in Algeria. Established in 1969, it not only has a monopoly over the distribution and sale of natural gas in Algeria, but also over the production, distribution, import and export of electricity[69]. With an inflated work-

66 Agence Ecofin, «Algérie : les recettes d'exportation d'hydrocarbures chuteront à 23 milliards $ en 2020 (gouvernement)», Agence Ecofin, https://www.agenceecofin.com/hydrocarbures/2207-78817-algerie-les-recettes-d-exportation-d-hydrocarbures-chuteront-a-23-milliards-en-2020-gouvernement.

67 «tendancesmonetaires_2semestre2018.pdf», 2, https://www.bank-of-algeria.dz/pdf/tendancesmonetaires_2semestre2018.pdf.

68 «Breakeven Oil Prices», Data IMF, 2019. https://data.imf.org/regular.aspx?key=60214246

69 «SONELGAZ sur euro-énergie», https://www.euro-energie.com/sonelgaz-e1-463.

force of 94,335 employees at the end of 2019 (3% more than the 2018 figure)[70], compared to the 10,000 workers employed by the Spanish company ENDESA, or the 70,000 workforce at the French EDF Group, the second largest energy producer and distributor in the world after China Energy Investment, Sonelgaz is in a difficult economic situation and has a large debt. In the words of its President and CEO of the Chahar Boulakhras Group, the debt reached 408 million Euros in 2019[71], which means that it is difficult to make the investments required to develop its energy networks and infrastructure that would enable it to improve the quality of its services and to meet the market demand.

Although only a drastic cutback in the number of workers and a modernisation of the company would enable it to survive, not only on the domestic market but also the regional and African markets, according to the Minister of Energy Abdelmadjid Attar (a former employee of Sonatrach), such a measure would be extremely unpopular in a country where employment offers are few and far between. Therefore, the solution seems to be more a question of lowering the salaries, which could prove to be more acceptable from a social perspective[72]. A foreign debt could also be a necessity, which according to its Chairman Chahar Boulakhras, «has become a necessity»[73], in the face of the difficulties the company is experienced when it comes to developing its energy networks and infrastructure, improving service quality and meeting the market demand.

The Sonatrach Group, (*Société Nationale pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures*) is a monopoly established to exploit hydrocarbons. It has 180,000 employees and produces 30% of Algeria's GDP. Although it is not in such a complicated financial situation as Sonelgaz, its operating and investment costs account for between 20 and 30% of its billing with an oil price standing at

70 «Sonelgaz : une entreprise citoyenne, une fierté nationale | ElDjazaircom», https://www.eldjazaircom.dz/2020/09/29/sonelgaz-une-entreprise-citoyenne-une-fierte-nationale/.

71 «Sonelgaz : La dette du groupe atteint 62 mds DA en 2019 - Algerie Eco», https://www.algerie-eco.com/2019/12/31/sonelgaz-dette-groupe-atteint-2019/.

72 Pedro Canales, «Algeria considering massive layoffs to modernize its industry», Atalayar, 24th July 2020, https://atalayar.com/content/Algeria-estudia-despidos-masivos-para-modernizar-su-industria.

73 Chellouf Thouraya, «Sonelgaz envisage de recourir à l'endettement extérieur», http://www.aps.dz/economie/92402-sonelgaz-envisage-de-recourir-a-l-endettement-exterieur.

65 dollars a barrel[74]. Therefore, it is a «rent-seeking» company that is far from being competitive in an open oil market on a global scale, especially if it is compared with other oil giants, such as Halliburton, which employs 55,000 people and has a turnover of 240,000 million dollars, compared to the Algerian firm's 40,000 million dollars[75].

The Minister and ex-CEO at Sonatrach, Abdelmadjid Attar, is relying on the hydrocarbons giant continuing to be the driving force behind the country's economy because it holds the monopoly in the sector, but if this is to be the case, major reforms are needed. The company «will have to reduce extraction and operating expenses», which are much higher than the world average, especially at a time when the fall in the price of natural gas is even sharper than the drop in oil prices. In the words of the Chairman of Naturgy Francisco Reynés, «gas prices are becoming increasingly disassociated with the price of oil, the difference between gas and oil prices in 2019 being 38%»[76]. If Sonatrach is to be competitive, it must restructure its activities, focusing on its main purpose of prospecting, production, transporting, processing and commercialisation of hydrocarbons, which means pulling out of other disassociated sectors where it operates such as air transport with the firm Tassili Airlines[77].

A new energy model for Algeria?

The sharp reduction that is expected in the total exports of natural gas and liquid natural gas (LNG) in the next few years -which according to the Minister Attar, could fall to 26-30,000 million

[74] Lagha Chegrouche, «Comment Khelil et Ould-Kaddour ont transformé Sonatrach en coquille vide - Algérie Patriotique», https://www.algeriepatriotique.com/2020/07/09/sonatrach-management-sclerose-infrastructures-vieillissantes-culture-rentiere/.

[75] Pedro Canales. Op cit.

[76] The average price of Brent and WTI oil fell by 21% and 17%, respectively, when compared to the first three months of 2019. At the end of the first quarterly period in 2020, the price of Brent was less than 20 dollars per barrel. The price of gas dropped even more sharply, with falls ranging from 36%, in the case of Henry Hub, and 56%, in the case of Algonquín. Juan Cruz Peña: «Spain turned off the gas tap on Algeria in the face of the knockdown prices of the vessels arriving from the USA», El Confidencial, 7th May 2020. https://www.elconfidencial.com/economia/2020-05-07/espana-cierra-grifo-gas-Algeria-precios-buques-eeuu_2583132/

[77] «Attar: des discussions pour résoudre le problème du flux de trésorerie de Sonatrach», http://www.aps.dz/economie/108757-discussions-avec-le-ministere-des-finances-pour-la-resolution-du-probleme-du-flux-de-tresorerie-de-sonatrach.

cubic metres per year in 2025-2030 when compared to the 40.9 billion cubic metres of gas and LNG that Algeria exported to Europe in 2019[78], indicates the urgency of the reform process that has to be carried out on the State-monopoly companies, starting with Sonatrach, which would enable production to be increased and would cut down on cost, while also encouraging diversification. It would be a question of introducing a new energy model in Algeria that would make it possible to revitalise this strategic sector, the driving force of the economy and main provider of the State budget.

This is the message that would appear to have been understood by the current Algerian Government, for whom the lack of development of new fields makes it paramount to review the legal system governing hydrocarbons, owing to a reduction in production volume and the increasing growth in domestic consumption. It is a situation described by the Ministry of Energy's Director General of Hydrocarbons, Mustapha Hanifi, as «a structural deficit between domestic supply and demand as from 2025… when 60% of the energy reserves will have been consumed for all the products combined»[79].

Hence, the first measure adopted by the new Algerian Government after winning the December 2019 Elections was to review the legal system affecting hydrocarbons, especially in contractual and fiscal matters, with passing on 11 December that same year, of a new Hydrocarbons Act whose aim is to prevent putting Algeria in a structural deficit situation between domestic supply and demand. It is a matter of renewing the reserves and keeping up production capacity at least throughout the transition period until 2030, for the purpose of which major investments and, above all, association with other international companies[80] must be made.

The new Act thus plans to conserve «Standard 51/49», which regulates Sonatrach's partnerships with foreign companies, consolidating the national company's monopoly as leader in the hydrocarbons research & operation sector, considered to be a

78 Sebastiano Torrini, «Algeria: Sonatrach conferma gli sforzi per incrementare la produzione di gas», Energía Oltre, 17 August 2020, https://energiaoltre.it/algeria-sonatrach-conferma-gli-sforzi-per-incrementare-la-produzione-di-gas/

79 Adlène Meddi, «Algérie : cette nouvelle loi sur les hydrocarbures qui ne passe pas - Le Point», https://www.lepoint.fr/afrique/algerie-cette-nouvelle-loi-sur-les-hydrocarbures-qui-ne-passe-pas-14-10-2019-2341125_3826.php.

80 «Les exportations d'hydrocarbures pourraient baisser dès 2023»: Toute l'actualité sur liberte-algerie.com».

strategic and highly sensitive social sector, but also limiting the potential for foreign investment[81].

However, the new Act also introduces three types of contracts in the sector, that potential international partners will find give them greater fiscal advantages, while at the same time enabling Algeria to share the risks – and the profits – linked to the prospection operations that Sonatrech is currently performing alone. To a certain extent, this amounts to a return to the successful system that existed in the previous Act 86/14 (1986) and that led to the major discoveries of hydrocarbons in the Berkine Basin in the 1990s. The fiscal advantages are even greater in the area of unconventional and offshore hydrocarbons, whose potential is promising in Algeria. Such measures could enable Algeria to renew its reserves and relaunch production activities, which would help to guarantee its energy security[82].

Furthermore, in 2019 the Algerian Government would have sought to give a degree of stability to the gas exports with the signing of several agreements by Sonatrach and its partners to renew gas contracts in the medium- and long-term[83]. Sonatrach signed a protocol with the Italian company ENI renewing Italy's long-term contract to supply Algerian natural gas. Sonatrach also signed an agreement with Edison (Italian as well) to renew a purchase & sale contract for Algerian natural gas for an 8-year period until 2027, which guarantees an investment level of 13,000 Mcm/year of natural gas delivered to the Italian market via the «Trans Mediterranean Gas Pipeline», allowing for the possibility of an extension until 2029. These two agreements will enable Sonatrach to consolidate its position on the Italian market, where it will continue to be one of that country's main providers of natural gas.

In 2019, Sonatrach signed agreements with the Portuguese company Galp Energia regarding the supply of Algerian natural gas to Portugal. The volumes concerned are 2,500 Mcm/year, extend-

81 Lazhar Sahbani, «Revue des principales mesures de la nouvelle loi sur les hydrocarbures en Algérie», PricewaterhouseCoopers Algérie, January 2020, https://pwcalgerie.pwc.fr/fr/files/pdf/2020/01/fr-algerie-pwc-loi-hydrocarbure-2020.pdf.

82 These are the participation contract, the shared production contract and the isk services contract. «- Entrée en vigueur de la nouvelle loi... - Europétrole», https://www.euro-petrole.com/entree-en-vigueur-de-la-nouvelle-loi-regissant-les-hydrocarbures-en-algerie-n-i-19983.

83 Badra Hafiane, «L'adoption d'une nouvelle loi des hydrocarbures marque le secteur de l'énergie en 2019», http://www.aps.dz/economie/99397-l-adoption-d-une-nouvelle-loi-des-hydrocarbures-marque-le-secteur-de-l-energie-en-2019.

ing for an additional 10-year period this bilateral agreement. Sonatrach also signed an agreement with the Spanish companies Cepsa and Naturgy to sell Cepsa's shares in the Medgaz Pipeline, which increased Sonatrach's shareholding in Medgaz from 43% to 51%. Finally, medium-to-long term agreements were signed with the French company ENGIE, regarding the purchase and sale of liquid natural gas and gas via pipeline.

Another course of action taken by the Algerian Authorities was to invest 78,000 million dollars in *upstream* activities until 2021, most of this being given over to prospecting and exploration. Recent exploration efforts proved to be fruitful, with the discovery of 17 oilfields and gas fields in the first five months of 2018, compared to 14 for the same period in 2017, in keeping with the sharp increase in discoveries since 2010 yielding 32 registrations in 2016 and a further 33 in 2017. At the same time, major amounts have been invested in modernising the mature fields such as Hassi R'Mel with 2,790 million until 2020; this has helped to ensure that the level of reserves still remaining, increased from 4,130 million toe[84] in 2017 to 4,190 million toe in 2018[85].

A new energy strategy

The SH2030 strategy «Lead the Change» launched in 2018 by Sonatrach, is based on a substantial change in its economic vision: the earlier strategy based on volumes of exports has become obsolete and has to be replaced by new markets with better added value[86]. This basically involves diverting 50% of the exports to the Asian markets to the detriment of Europe. To achieve this, Algeria intends to utilise the remaining export capacity of liquid gas – which in 2018 amounted to 44% of the total capacity – to cater for exports to potential Asian markets.

However, having the infrastructure makes no sense if the availability of gas for export at competitive prices is not increased. In an international market saturated with new and more aggressive competitors, such as Qatar, Nigeria, the USA, Australia, or Mozambique, all of which are able to sell liquid gas to Europe for

84 Oil-equivalent tonnes.

85 «The Report Algeria 2018», 79.

86 «Sonatrach, l'énergie du changement», https://sonatrach.com/actualites/sonatrach-une-strategie-dexportation-prenant-davantage-en-compte-laspect-valeur-et-non-plus-seulement-celui-de-volume/.

less than 6 $/MMBtu[87], it will be very difficult for Algeria to export more than small quantities on an occasional basis to the Asian markets and even hold to its share of the European markets[88].

That is why Sonatrach has set a target to generate 20,000 million cubic metres of unconventional resources for 2030 and 70,000 million for 2040, as well as to explore an offshore area covering 100,000 square kilometres along the Algerian Coast. Yet this cannot be done without attracting other companies to the bidding rounds for the energy fields, and the ability to do this will depend on the success of its policy of dealing with foreign companies bilaterally and abandoning public tenders[89].

	Project	**Commissioning**	**Expected production**	**Consortium**
South West Gas Fields	Reggane Nord	December 2017	4.5 Bcm/year	Repsol (29.25%), Sonatrach (40%), DEA Deutsche Erdoel AG (19.5%) and Edison (11.25%).
South West Gas Fields	Timimoun	March 2018	1.8 Bcm/year	Sonatrach (51%), Total (37.75%) and Cepsa (11.25%)
	Erg Issouane gas field	October 2018	100 million oil-equivalent barrels.	Total, Repsol, Sonatrach.
Illizi (SE)	Ain Tsila liquefied gas field.	March 2019	4 Bcm/year	Isarene (Sonatrach, Petroceltic and Enel), Petrofac
South West Gas Fields	Touat	September 2019	4.5 Bcm/year	Sonatrach, Neptune Energy

87 1 MMBtu is equal to 1 million BTU (British Thermal Unit). Natural gas is measured in MMBtu. 1 MMBtu = 28.263682 m3 of natural gas at defined temperature and pressure.

88 «GNL: Sonatrach envisage d'augmenter ses exportations vers l'Asie - Algerie Eco», https://www.algerie-eco.com/2018/11/23/gnl-sonatrach-envisage-daugmenter-ses-exportations-vers-lasie/.

89 «Sonatrach Unveils 2030 Strategy, But Can It Be Implemented?», Hart Energy, https://www.hartenergy.com/exclusives/sonatrach-unveils-2030-strategy-can-it-be-implemented-30359.

	Project	**Commissioning**	**Expected production**	**Consortium**
Arzew	Sonatrach-Total Entreprise Polymère	November 2018	Transformation of 550,000 tons / year of propane into 640,000 tons of polypropylene	Sonatrach-Total Enterprise Polymeres (STEP)
Bir Rebaa Nord field	10-MW solar photovoltaic power plant	October 2018	20 GWh	Sonatrach
Arzew	Phosphate complex to begin operations in 2022.	November 18	5 million tonnes per year,	Sonatrach, CITIC (China)
Tiaret,	Refinery and joint petrochemical firm	January 2019		Total
Hassi Ba Hamou and Reg Mouaded; Hassi Tidjerane and Hassi Tidjerane Ouest; and Tinerkouk Ouest	Three central processing facilities for three groups of fields	February 2019,	4 Bcm/year	Sonatrach, Larsen & Tourbo Hydrocarbon Engineering Limited
	$3.7bn «greenfield» refinery	January 2020		

Table 1: Investment / Production Summary
Source, Website data from the companies and miscellaneous articles

Yet even if the new gas projects in the south-west and in the new producing region in the south-east of Illizi are able to provide almost 19 Bcm per year for midway through the 2020s, they would be insufficient to cater for a domestic natural gas demand that is expected to increase by 21 Bcm in 2028, from the 46 Bcm available in 2018.

Furthermore, it is not sufficient for Algerian gas to carry on being competitive in cost for export to Europe. The export terms and conditions have to be just as flexible as those of its competitors, to adapt to the new gas market realities where prices are set on the basis of the cost at the production centres, contracts are signed for shorter periods and where those contracts contain renegotiation clauses that depend on how market conditions evolve[90].

Neither do past memories of delays and non-fulfilments in the performance of projects already approved by Sonatrach give cause for optimism. By way of example, its largest contract awarded recently, a $3,700 million agreement signed at the beginning of January 2020 to construct a completely new refinery was first considered more than seven years ago. A second refinery planned a long time ago in Tiaret, and a petrochemical facility agreed with the main French company Total early in 2019, after years of intermittent negotiations, are among the investments that will probably not see the light for several years[91].

Algeria is making a great effort to develop its gas pipeline network increasing its export capacity[92]. As a result, in February 2018 a new 765 km gas pipeline was opened connecting Reggane North and the GR5 compression station at Hassi R'Mel operating since July 2017. Other enlargements to gas pipeline networks are also being undertaken such as the $274 million construction of a new 200 km long line between El Aricha and Beni Saf, completed in August 2020, whose development will allow gas from the Maghreb-Europe gas pipeline to reach MEDGAZ. A consequence of this project will be to increase the capacity of the latter from 8,000 million cubic metres a year, to 10,000 million cubic metres a year[93].

Another option is to develop unconventional resources in the form of shale gas, which could become a pedestal in Algeria's future energy sector[94]. However, exploitation attempts have been strongly resisted by local inhabitants, whose livelihoods in the desert terrain depend on water supplies pumped from a

90 «Algerian Gas in Transition», Ouki y Oxford Institute for Energy Studies, 18.

91 «Algeria's upstream rebirth is interrupted», https://www.petroleum-economist.com/articles/upstream/exploration-production/2020/algeria-s-upstream-rebirth-is-interrupted.

92 At present, all the gas produced in Algeria is sent to the national gas distribution centre at Hassi R'Mel, from where the aggregate gas supplies are sent via the gas pipelines that run to Spain or Italy, or to the LNG plants in the north.

93 «The Report Algeria 2018», 79.

94 In 2014, Sonatrach drilled two exploratory shale gas wells close to the city. The results were described by the then Minister of Energy, Youcef Yousfi, as «very promising» and proof of the fact that they were «resource that were worth exploiting». http://fracturahidraulicaenburgosno.com/los-suenos-de-gas-de-esquisto-de-Algeria-son-una-pesadilla-para-los-lugarenos/

deep aquifer system underneath the Sahara[95]. In an effort to placate the population, on 23 January 2020 the President of Algeria, Abdelmajid Tebboune, stated that: «Shale gas is necessary» and gave the US as an example where «the shale gas wells are drilled in the middle of areas that are surrounded by residential houses»[96]. In spite of this, it will be difficult to convince the locals about the advantages.

At the same time, since 2011, Algeria has made the development of renewable energies a national priority with the National Renewable Energies Development Plan. Algeria has a high insolation level, more than 3,000 hours of sunlight per year, and an extremely high average insolation reaching 5 KWh/m^2 per day, which increases to 6.2 KWh/m^2 in the southern region, making Algeria the country with the greatest solar potential in the MENA Region and one of the highest in the world.

The plan involves installing by 2030, a renewable capacity of around 22,000 MW, which will amount to 27% of the national energy mix, with an export option remaining open, if market conditions so permit[97]. With a view to this, Sonatrach plans to invest 1,900 million dollars in renewable energies between 2019 and 2023 in order to achieve an installed generation capacity of 1.3 GW. Algeria's immense solar potential could cater for domestic demand, relieving the pressure on gas consumption while at the same time generating growing exports as production costs continue to fall[98].

Wind energy has only been developed to a limited extent, because it is less profitable than solar energy, given that it varies on the basis of the wind speed, which in Algeria is relatively moderate, the annual average being 9.7 km per second. Moreover, the cost of wind farm maintenance in the Sahara is much higher. At present, Algeria has only one wind farm in the whole country, constructed in 2014 in Kabertene in the *wilaya* of Adrar, with a generation capacity of 10 MW.

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95 Algeria is one of the most water-stressed countries in the world, with 300 litres of water per inhabitant compared to the world average of 7,000. This level is expected to be halved by 2050. Ghanimah Al-Otaibi, «In figures: facts about the water crisis in the Arab world», World Bank, 19 March 2015. https://blogs.worldbank.org/arabvoices/numbers-facts-about-water-crisis-arab-world

96 «The ins and outs of shale gas», https://atalayar.com/blog/los-entresijos-del-gas-de-esquisto.

97 «Ministry of Energy | Algérie», https://www.energy.gov.dz/?rubrique=energies-nouvelles-renouvelables-et-maitrise-de-lrenergie.

98 «The Report Algeria 2018», 80-81.

It could be said that renewable energy development is taking place very slowly, and that Algeria is far from making renewable energies form part of the national energy mix.

Energy in Libya. War, power and oil

Without oil Libya does not exist

Without hydrocarbons, Libya might not even exist. Without oil and gas, there would be no work, no wages, no food and, what is more, there would not even be any war. Oil pays for Libya's food imports, which amount to 20% of the total[99] and the salaries in a public sector, which account for over 80 % of the work force[100]. Oil also finances however the struggle for power between rival groups that has been going on since 2011[101]. Libya is a country where the revenue from hydrocarbons accounts for 97 % of the GDP, 97% of the revenue from exports and 99% of the Government's revenue[102], a proportion much higher than in any other Arab oil-exporting country. As Ghassan Salame, the UN envoy to Libya, stated in November 2018 before the UN Security Council, the Libyan conflict is, to a large extent, «a conflict over resources».[103] In this sense, energy stability can only be achieved if the conflict is solved.

This is particularly important when considering Libya's oil production prospects. There are three reasons for this, the first being that the actual Libyan economy is more closely linked to international oil prices than the economies of other oil exporters, which makes the country particularly vulnerable to economic shocks and to external variations in oil prices. The second reason is that the civil conflict situation in the country, aggravated by the presence of foreign stakeholders, causes the prospects of greater growth in production dependent on an agreement between the contenders in the conflict about the best way to manage Libya's current and potential resources. The third reason implies that the

[99] «FAOSTAT», http://www.fao.org/faostat/en/#country/124.

[100] «MENA Quarterly Economic Brief», The World Bank, January 2014, p.18.

[101] Chris Stephen, «Partition of Libya looms as fight for oil sparks vicious new divide», The Observer, Sunday 16th March 2014. http://www.theguardian.com/world/2014/mar/16/libya-partition-looms-fight-oil-tanker.

[102] «2015 Index of Economic Freedom», The Heritage Foundation, January 2015. http://www.heritage.org/index/.

[103] APICORP_Energy_Research_V03_N14_2018.pdf», https://www.apicorp.org/Research/EnergyReseach/2018/APICORP_Energy_Research_V03_N14_2018.pdf.

reaching of a settlement between the opposing sides in Libya and the international partners would act as a great incentive for the country's energy sector, which could prosper rapidly generating increased flow of oil and more revenue.

Libya has an extensive network of refineries dotted all along the Mediterranean Coast, consisting of[104]:

- Az Zawiya Refinery: lying in the north-west of Libya, with a crude oil processing capacity of 120.000 bbl/d[105].
- Ras Lanuf Export Refinery: lying in the Gulf of Sirte, with a crude oil refining capacity of 220.000 bbl/d.
- Tobruk Refinery: located along the Libya's eastern coast, with a crude oil capacity of 20.000 bbl /d.
- Brega Refinery: lying in the north-east of Libya, with a crude oil capacity of 10.000 bbl/d.
- Sarir Refinery: a back-up plant, with 10.000 bbl/d.

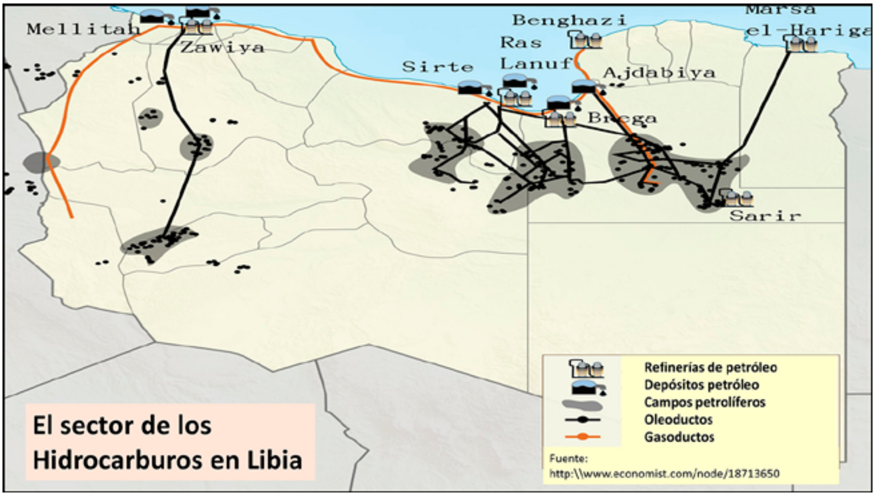

Figure 8. The hydrocarbon sector in Libya. (Source : http:\\www.economist.com/node/18713650).

Gas production and export commenced in 2003, the year in which the Western Libya Gas Project got under way, which led to the commissioning of the 370-mile gas pipeline «Greenstream» in 2004, jointly run by the Italian State-owned company ENI and the Libyan National Oil Company (NOC), whose operation from

104 «Libyan Oil & Natural Gas, https://www.temehu.com/oil-gas.htm.

105 Abbreviation for barrel of oil per day, a volume of 42 US gallons [0.16 m3].

Mellitah in the west of Libya and Gela in Sicily makes it possible to understand why Italy immediately supported the Government in Tripoli after the fall of Gaddafi[106]. The gas flow was interrupted during the initial phase of the war in 2011, for eight months, and began to recover in 2012, but it has never returned to the levels it reached before hostilities broke out.

Something similar has happened with liquid natural gas (LNG); Libya, Algeria and the USA (Alaska) were pioneers in exporting to foreign markets, mainly Spain. However, during the revolution, the only LNG Plant constructed in Marsa-Al-Brega, owned by NOC and operated by Sirte Oil Company, was badly damaged at the beginning of 2011, so exports were interrupted. However, its production never exceeded one third of its maximum capacity, mainly because of technical limitations[107].

Libyan oil ports, fields, refineries and operators (2020)					
Loading ports	**Region**	**Main fields**	**Refinery**	**Operator**	**Main partners**
Es Sider (Sidra)	Central-East	Waha, Samah, Dahra, and Gialo		Waha Oil Company	ConocoPhillips, Marathon, Hess
		Mabruk (Mabrouk)		Mabruk	Total
Ras Lanuf	Central-East	Nafoura		Agoco	none
		As Sarah/Jakhira b(C96), Nakhla (C97)[1]		Wintershall	Wintershall, Gazprom
		Amal, Naga, Farigh		Harouje	Suncor (PetroCanada)
Marsa al-Hariga (Tobruk)[2]	East	Sarir, Messla, Beda, Magrid, Hamada[3]	Ras Lanuf; Tobruk; Sarir	Agoco	none
Zueitina	central-east	Abu Attifel, NC-125		Mellitah	Eni
		Nakhla (C97)[1]		Wintershall	Wintershall, Gazprom
		Intisar Complex and NC74[4]		Zueitina Oil Company[5]	Occidental, OMV
Marsa al-Brega	Central-East	Brega (Nafoura/ Augila complex)	Marsa al-Brega	Agoco	none

[106] «Che cos'è il gasdotto Greenstream - InsideOver», 29 December 2018, https://it.insideover.com/schede/politica/cosa-e-greenstream.html.

[107] The Plant does not have the technology to separate some liquid gases from the liquefied LNGs, which limits the number of receiving terminals able to process the latter.

Libyan oil ports, fields, refineries and operators (2020)					
Loading ports	**Region**	**Main fields**	**Refinery**	**Operator**	**Main partners**
		Nasser (Zelten), Raguba, Lehib (Dor Marada)[6]		Sirte Oil	none
Mellitah	West	El Feel (Elephant), mixed with condensate from Wafa and Bahr Essalam gas fields		Mellitah	Eni
Zawiya or Zawia (Tripoli)	West	El Sharara (NC-115 and NC-186 fields)	Zawiya	Akakus	Repsol, Total, OMV
Bouri[7]	West	Bouri (offshore)		Mellitah	Eni
Farwah (Al-Jurf)[7]	West	Al-Jurf (offshore)		Mabruk	Total

1 The oil from Nakhla (C97) is mixed with the product from Eni´s Abu Attifel Field.
2 Most of the production from the Agoco Fields can be sent to Ras Lanuf and Marsa al Hariga (Tobruk).
3 The oil from the Hamada Field, which is in the West, is sent to Zawiya. This oil is normally used in the country.
4 The oil produced in NC74 is sent to Ras Lanuf.
5 The crude oil from Zueitina can also be sent to the terminal at Ras Lanuf.
6 Production from Lehib is mixed with the output from one of the Harouje Fields and sent to Ras Lanuf.
7 Bouri and Farwah (Al-Jurf) are offshore loading terminals for Mellitah.

Table 2. Libyan oil ports, fields, refineries and operators (2020) Sources: U.S. Energy Information Administration based on data from Energy Intelligence, Middle East Economic Survey (MEES), company websites, Oil & Gas Journal, and Lloyd's List Intelligence (APEX tanker data).

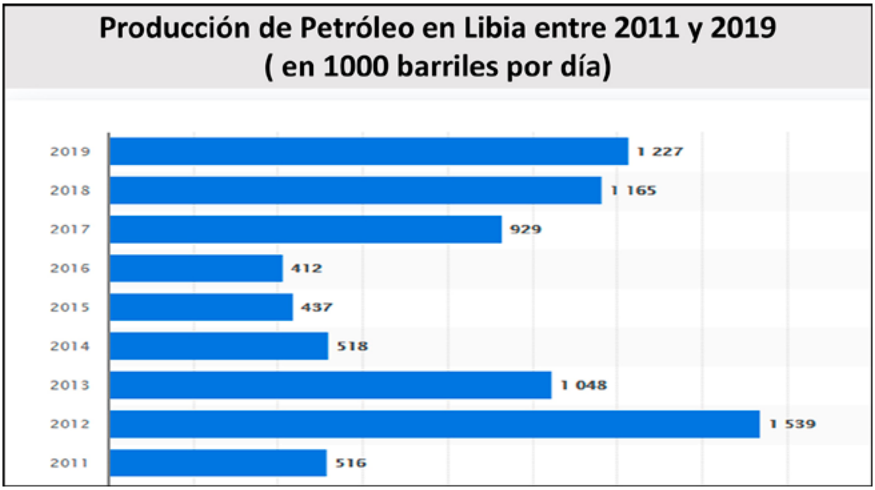

Figure 9. Oil production in Libya between 2011 and 2019. Source:https://www.statista.com/statistics/265194/oil-production-in-libya-in-barrels-per-day/.

Yet the great advantages offered by the high quality of Libya's oil, the ease with which it can be extracted and the proximity of the consumer markets in Europe, are counteracted by the fact that hydrocarbon production and exports in Libya have been badly affected by the conflict in recent years, and the situation has undergone many ups and downs depending on the way the military situation has been evolving. This can be analysed by dividing the history of Libyan hydrocarbons since 2011 into four major periods.

1st PHASE: Upheaval followed by relative stability

Before the 2011 Revolution, Libya had major plans to increase its production: initially up to 1.7 million bbl/d, and later to increase this quantity still further to 2 million bbl/d. Yet this amount was way below the maximum levels of over 3 million bbl/d reached at the end of the 1960s, the period when oil production in Libya was affected by the partial nationalisation of the industry and by the sanctions imposed by the US and the United Nations, which prevented the investment needed to keep oil production at its highest levels.

The lifting of the international sanctions, imposed after the Lockerbie Air Disaster in 1984, enabled in 2004 the oil companies to return, leading to a rise in production from 1.4 million bbl/d in 2000 to 1.74 million bbl/d in 2008, and it also made it possible for the country to launch an investment programme as from 2009, which included plans to open 23 new oilfields, adding 775,000 barrels of oil per day[108].

In spite of this, the deterioration of the security situation prompted by the Revolution upset these highly ambitious plans. In 2011 hydrocarbon exports from Libya were almost completely interrupted during the Civil War, while at the same time the annual gross domestic product decreased by 62%[109]. Annual production fell from 1.8 million barrels before the war, to just over 500,000

108 As-Shafir, «Libyan Militias Control the Oil Industry», Al-Monitor, 14 February 2014. http://www.al-monitor.com/pulse/security/2014/02/libya-oil-industry-control-militias.html.

109 «IMF Country Report No. 13/151, Libya», International Monetary Fund. May 2013. https://www.imf.org/external/pubs/ft/scr/2013/cr13151.pdf.

barrels in 2011, and these quantities were mainly consumed domestically[110].

This period of great instability coinciding with the fall of Gaddafi did not last very long, and the oil production lost during the Civil War recovered rapidly in view of the limited damage caused to the energy infrastructure. The first phase after the fall of Gaddafi, which lasted from mid-2011 to mid-2013, was characterised by being a period of relative stability, which demonstrated how resilient the Libyan energy sector was, once again achieving a growth in production that reached more than 1.4 million bbl/d in just over six months. It was an amazing recovery, but it would not be the last time that the country was to surprise foreign analysts[111].

Those years included elections to form a new Government and efforts to draw up a new Constitution. Even so, the major problem, from the very outset, was that the new Libyan Government showed itself to be unable to deactivate the militias that had emerged in the struggle against Gaddafi. Each one of these groups had its own ideology and retained its own tribal loyalties, so every armed group used its power to try and impose its own demands. Little by little these militias were gaining control over security in the cities and at the frontiers, as well as controlling management of the detention centres and country's energy facilities[112].[]

As the Libyan Government was unable to get rid itself of the militias, it used the most important ones to combat the tribal and ethnic struggles that were tearing apart extensive zones in the country, and it did so grouping together the most powerful local militias into one single structure that it called the «Libya Shield Force» placing it under the Government's payroll and splitting it into three geographical areas (West, Centre and East). This was tantamount to creating three military divisions[113]:

- Libya Shield 1, in the Cyrenaica Region, which in 2014 came to form part of the Shura «Council of the Benghazi Revolutionaries».

110 «International - U.S. Energy Information Administration (EIA)», https://www.eia.gov/international/analysis/country/LBY.

111 «APICORP_Energy_Research_V03_N14_2018.pdf».

112 *Rosa Meneses,* «Libya, under the law of the armed militias«, El Mundo, 20 October 2013. http://www.elmundo.es/elmundo/2013/10/17/internacional/1382027510.html.

113 Ignacio Fuente Cobo, «LIBYA, the war of everyone against everyone», s. f., 19.

- The Western Libya Shield, linked to the Al-Qaeda leader Ibrahim Ali Abu Bakr[114] and which was to play a major role in April 2014, in the occupation of Camp 27 to the west of Tripoli, the main base set up by the USA to train the Libyan Army.
- The Central Libya Shield, involved in August 2014 in the taking of Tripoli Airport, which was also known as the Misrata Brigades[115].

The absence of a real security structure meant that bit by bit the situation deteriorated, without the new Authorities being able to assert themselves. On 11 September 2012 the US Consulate was attacked in Benghazi, resulting in 4 deaths including the Ambassador Christopher Stevens, and a few months later in April 2013, the French Embassy in Tripoli was attacked by a terrorist commando.

The attack occurred in the Tripolitania Region, but the situation was not evolving any better in the east of the country. The Muslim Brotherhood, who had been ousted from Egypt by General Al Sissi's Government, was becoming increasingly influential in that zone, where it had found an excellent sanctuary among its Libyan coreligionists[116]. The same could be said for the terrorists of Al-Qaeda, who had become particularly strong in the most easterly area of the country, from Benghazi to the City of Derna, where «no Libyan civil servant could dare to tread and remain alive»[117].

2nd PHASE: division and civil war

Midway through September 2013 a potentially explosive situation had been reached, with intermittent confrontations between the Islamic forces and their opponents who were secular, to a greater

[114] Tantoush was involved in the attacks against the US Embassies in Kenya and Tanzania in August 1988. See United Nations Web Services Section, Al Jazeera, 23 August 2014, http://www.un.org/sc/committees/1267/NSQI05702E.shtml.

[115] «Tripoli airport 'seized by Islamist militia», Al Jazeera, August 2014, http://www.aljazeera.com/news/middleeast/2014/08/tripoli-airport-2014823183122249347.html . Also Stephen Chris and Penketh Anne, «Libyan capital under Islamist control after Tripoli Airport seized», The Guardian, 24th August 2014, http://www.theguardian.com/world/2014/aug/24/libya-capital-under-islamist-control-tripoli-airport-seized-operation-dawn.

[116] Jean Francois Galletout, «Libye: trois ans après, faul-il y retourner?», Le Figaro, 19th August 2014, http://www.lefigaro.fr/vox/monde/2014/08/19/31002-20140819ARTFIG00302-libye-trois-ans-apres-faut-il-y-retourner.php?pagination=4.

[117] Samuel Laureant, «La Libye, un «nid de guêpes où il est imposible d´intervenir», France 24, 18th August 2014, http://www.france24.com/fr/20140817-libye-tripoli-chaos-violences-intervention-onu-misrata-milices-islamistes-zenten-khadafi/#./?&_suid=141033159237403126821379664939 6.

or lesser extent. Moreover, such clashes also occurred between the different regions in the country, and even between different towns. The country was thus embarking on a second phase of political division and a civil war, which was to last until 2016.

The different militias were quick on the uptake when it came to learning the importance of hydrocarbons as a political tool. Halfway through 2013, the Petroleum Facilities Guard (PFG), which was responsible for safeguarding the key oil export infrastructure, turned itself into a militia composed of 16,000 combatants knowns as the Barca Army, led by Ibrahim Al Jadran, an extremely anti-Islamic warlord, who took control not only over the oil facilities, but also over the ports in the Cyrenaica Region from which the oil was exported. The strategic Uad Rojo in the central district of Sirte, also fell into his hands, which threatened to partition the country by closing the four main oil-exporting terminals in the «oil crescent» in the Sirte´s Basin, Libya's most important oil zone.

In August, the two main loading ports of Sidra and Ras Lanuf and Tobruk (Harika Port) came to an almost total standstill in the central and eastern zones, from which 60% of the Libyan resources were exported. What was more, in the western region, the Zintan militias cut off the two main oil pipelines connecting the El Sharara and El Feel (Elephant) fields to the export terminals of Zawillah and Mellitah respectively, which put a stop to all production[118]. As a result, oil production fell from 1,000,000 bbl/d in July 2013, to 600,000 bbl/d in August, and then to a minimum of 200,000 bbl/d by the middle of September[119]. Closure lasted until September 2016[120] when all the attempts by the separatist leader Al-Jadran to sell oil on his own account had proved to be just as fruitless as his attempts to have his political demands met[121].

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118 «Libya Overview», EIA, US Information Administration. 10 October 2013. http://www.eia.gov/countries/cab.cfm?fips=ly.

119 Most of Libya's crude oil is sold to European countries. In 2012, approximately 71% of Libyan exports were sent to Europe; the main receivers were Italy, Germany, China, France and Spain. The USA resumed its oil imports from Libya in 2004, after sanctions had been lifted, importing 56,000 bbl/d of crude oil from Libya in 2012, which amounted to approximately 0.6% of the USA's total imports in that year.

120 Ibrahim al-Jadrán became popular during the revolution as a guerrilla leader in defence of Benghazi.

121 Geoff D Porter, «Stopping a Civil War in Libya», Politico Magazine, 19 March 2014, http://www.politico.com/magazine/story/2014/03/remember-libya-104782_Page2.html.

In the centre and east of the country, the rivalry between the various factions submerged the eastern cities of Benghazi, Derna and Sirte into a wave of murders and terrorist attacks described as a «terrorist war carried out by Libyans and foreign combatants»[122]. Interruptions to production became increasingly frequent, given that the armed militias established a pattern of closing oilfields and infrastructures in an attempt to demand higher salaries and to improve conditions. Insecurity at the two export terminals of Ras Lanuf and Sidra reduced output, so oil production between the mid-2013 and September 2016 averaged 390,000 bbl/d, less than a quarter of the production figure in 2010[123], while at the same time oil exports dropped to 830,000 bbl/d barrels per day in July and 445,000 bbl/d in August 2013[124].

As the militias were aware of the weakness of the central Authorities, they went one step further and tried to sell hydrocarbons directly on the international markets. Although the capture of the oil tanker Morning Glory by the Barca Army in March 2014 in the Cyrenaic port of Es Sider, was thwarted by the intervention of special US troops[125], it was indicative of the extent to which the struggle between the Central Government and the regional militias had escalated, when it came to controlling the energy resources[126].

In general, it can be said that the purpose of the attacks against the oil facilities during this first post-revolutionary period was not to seize the revenue from the installations or damage them, but to deprive the Government of them, thereby forcing the latter to accept the attacking group's demands. Cases of groups with social or economic demands applying blockades or occupying oil and gas facilities abounded from 2012 until 2014, and these also included protests at the Arab Gulf Oil Company (Agoco) in Benghazi, at the Mellitah Oil & Gas, at the Zawiya Petróleum Refining Company, in the Sharara oilfield, and at the el-Feel (Elephant) oilfield.

122 Marcos Suares Sipman, «Libya, immersed in chaos, seeks international aid to combat terrorism», EcoDiario.es, http://ecodiario.eleconomista.es/internacional/noticias/5645878/03/14/Libya-inmersa-en-el-caos-pide-ayuda-internacional-para-combatir-el-terrorismo.html#Kku8m4Xo35Rhg7Ge.

123 «APICORP_Energy_Research_V03_N14_2018.pdf».

124 Trading data from the Atlas Global Comercial and Datos de Petróleo (APICE).

125 «USA TODAY», https://eu.usatoday.com/story/news/world/2014/03/17/us-navy-seal-morning-glory-seizure/6513669/.

126 Ibrahim al-Jadrán became popular during the revolution as a guerrilla leader in defence of Benghazi.

On a political level, in December 2013, an increasingly Islamised General National Congress imposed Sharia Law[127] and decided unilaterally to extend its mandate beyond the 18 months to which it had committed itself and that was due to end in January 2014. These decisions merely served to exasperate still further the animosity between the different sectors of Libyan society, which opposed the Islamic path that the country was being taken down. The foundations for the «perfect storm» had been laid and civil war was about to break out.

June 2014´s Elections gave a further boost to the politicisation of the Libyan hydrocarbon sector. The outcome of the Elections by the end of 2014 was two different Governments, one, the General National Congress (GNC) in Tripoli and the other, the House of Representatives (HoR) in Tobruk, which created a totally unsustainable situation. As both Governments depended for their survival on the revenue from hydrocarbons, and this was invariably channelled through the Libyan Central Bank, the struggle between the two worsened, as each Government tried to deprive the other of this exclusive source of financing.

A military confrontation to gain control over the oil revenue became inevitable in view of the uncompromising attitudes of the two Governments. However, it was possible to partly lower this risk by paying the State salaries to all the combatants in the militias, regardless of the religious affiliation or political loyalties. Both Governments conserved the neutrality of the National Oil Corporation (NOC) and the Libyan Central Bank in order not to politicise the energy sector.

Faced with this chaotic situation, international community pressure led by the United Nations forced the reaching of a peace agreement on 17th December 2015 in the Moroccan City of Skhirat. The Agreement came to be known as the «Libyan Political Agreement» (LPA) and was signed by representatives of the two parliaments that were operating simultaneously and antagonistically in the country, i.e., the General National Congress (GNC) and the House of Representatives (HoR). The Agreement envisaged the forming of a «Government of National Accord» consisting of thirty-two members and directed by the secular and pro-Western

[127] Bosalum Feras, Patrick Markey, «Libyan assembly votes to follow Islamic Law», Reuters, 4 December 2013, http://www.reuters.com/article/2013/12/04/us-libya-law-idUSBRE9B30M220131204.

politician Fayez al Sarraj[128], who was also Chairman of the Presidential Council, as Head of State. The Accord also stipulated that a High Council of State of an advisory nature be established in Tripoli, which would be composed of representatives of the GNC. Meanwhile, the HoR would be recognised as the only legitimate Parliament in Libya.

Although since the Government of Fayez al-Sarraj was established in Tripoli in March 2016, all the State institutions should have come to form part of it according to the agreement reached in Skhirat, this was not the case, its authority being questioned from the very outset in the internal sphere. Even so, al-Sarraj was able to take an important step towards consolidating his power base because he was able to rely on the loyalty of the two most powerful economic institutions, the Central Bank and the National Oil Corporation, as well as the support of several municipalities in the west and south of the country.

The other centre of power, namely the House of Representatives (HoR) or «Tobruk Parliament», as the only legislative body, should have replaced the previous General National Congress (GNC), according to the Skhirat Accords, but this did not happen. In fact, the HoR decided to appoint the charismatic General Jalifa Hafter as the Chief of the Libyan National Army (LNA). It was Hafter who in February of that same year had launched «Operation Dignity» with a view to «purging» the country of the Islamists belonging to the Muslim Brotherhood[129].

Since then, the HoR has been giving its unconditional support to General Hafter, who has become the real strongman in eastern Libya[130] in opposition to the Government in Tripoli. Although General Hafter promised to eradicate political Islam and take overpower as the new military governor of Libya, the truth of the matter is that he allied himself with a rival faction of Saudi-style ultra-conservative Salafis[131].

128 «National Unity Government announced», Libya Herald, 19 January 2016, https://www.libyaherald.com/2016/01/19/national-unity-government-announced.

129 «Jalifa Hafter: The Libyan general with big ambitions - BBC News», https://www.bbc.com/news/world-africa-27492354.

130 «Profile: Libya's Military Strongman Jalifa Hafter», BBC, 15 September 2016. http://www.bbc.com/news/world-africa-27492354.

131 «The White House Blessed a War in Libya, but Russia Won It - The New York Times», https://www.nytimes.com/2020/04/14/world/middleeast/libya-russia-john-bolton.html.

As if the political situation were not already sufficiently serious as a result of the low-intensity conflict between the governments of Tobruk and Tripoli, at the beginning of 2015, a new and extremely violent Jihadist threat started to spread, complicating the situation in the energy sector. In February of that year, a group proclaiming their loyalty to Daesh stormed the Mabruk Oilfield, operated by a Joint Venture comprising the national company NOC and TOTAL[132]. Twelve workers died in the attack and another seven were taken prisoner. Furthermore, the facilities were deliberately damaged, something that had not happened before.

Ten days after, these facilities were attacked again, at the same time as the storming of the Bahi oil field, operated by another Joint Venture consisting of NOC and Oasis[133]. The following day an oil pipeline connecting the Sarir oilfield with the Marsa Hariga terminal, operated by AGOCO, was bombarded causing an explosion that forced it to close down. This attack was a carbon copy of the *modus operandi* utilised the month before in January 2015 by the Jihadist Group Ansar Bayt al-Maqdis, a subsidiary of Daesh, on the Sinai Peninsula, when it attacked an Egyptian gas pipeline in that zone.

All these incidents serve to show a strategic change in the Jihadist groups, when compared to early strategies adopted by the various militias, for whom pressure on the hydrocarbon sector had hitherto constituted a way of carrying out political claims. In Libya, none of these Jihadist attacks sought to capture or control the oil or gas infrastructures, their aim was to destroy them[134].

As part of this new strategy, in March 2015 Daesh attacked and damaged several oilfields in the Al-Ghani zone, which forced the Tobruk Government to stop production in eleven oilfields in the central basin of Sidra. Eleven guards were murdered, several of whom were decapitated.

However, the Jihadist threat was greatly weakened when the Tripoli Government ousted Daesh from the Port City of Sirte[135].

132 Geoff D Porter, «Terrorist targeting of the Libyan oil and gas sector», Combating Terrorism Center at West point, 27 February 2015, https://www.ctc.usma.edu/posts/terrorist-targeting-of-the-libyan-oil-and-gas-sector.

133 Oasis is a consortium of North American companies, Hess, Marathon, and ConocoPhillips.

134 Patrick Markey, Ahmed Elumami, «Islamic State risk for Libya's troubled oil sector», Reuter, 28 October 2015, http://www.reuters.com/article/2015/10/28/us-libya-energy-idUSKCN0SM0HW20151028#bjDeHlAhyGhqcL8t.97.

135 Hani Amara, «Libyan Forces Clear Last Islamic State Holdout in Sirte», Reuters, 6 December 2016. http://www.reuters.com/article/us-libya-security-sirte-idUSKBN13V15R.

On 18 September 2016, a coalition of militias, mainly from the coastal city of Misrata, launched Operation Al-Bunyan Al-Marsous («Solid Foundation»)[136], whose objective was to force Daesh to leave the Gulf of Sidra Coast. The militias from Misrata, with considerable support from western forces, especially US air support, took Sirte, the last bastion of the Daesh organisation, on 6 December 2016, after an offensive lasting several months. Even so, it proved to be a Pyrrhic Victory, because it exacted a very high toll in human life (700 dead among the besieging forces and 2,500 Jihadists[137]). It was also ambiguous, given that it had been achieved thanks to the mobilisation of the militias, not by an integrated national army.

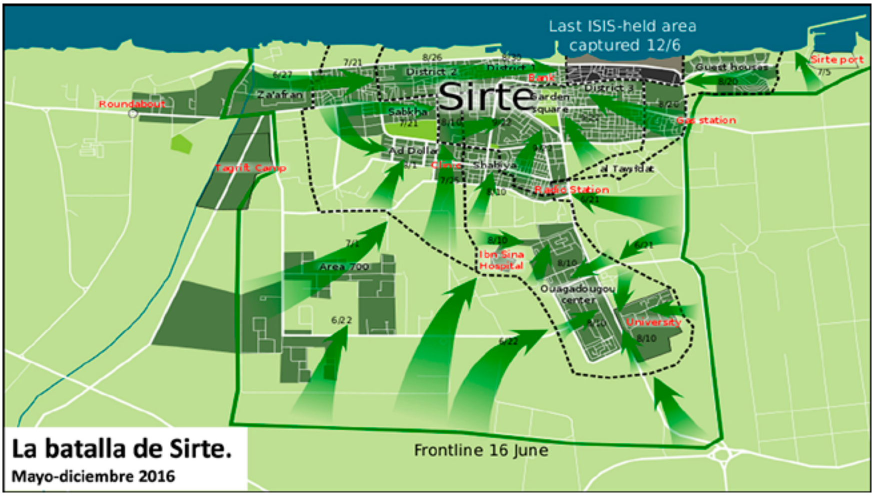

Figure 10. The Battle of Sirte. Source: the Creative Commons Attribution-Share Alike 4.0 International.

The weakened state of the Tripoli Government's military forces in their fight against the Jihadists of Daesh was used by General Hafter to his own advantage, and he attacked. By the end of 2016, the Libyan National Army had seized most of the Gulf of Sidra, defeating the militias of Al Jadram, so the former now

[136] «Libyan Troops Clash with ISIS Militants Leaving 6 Dead and 17 Injured», Libyan Gazette, 17 May 2016, https://www.libyangazette.net/2016/05/17/libyan-troops-clash-with-isis-militants-leaving-6-dead-and-17-injured/.

[137] Frédéric Bobin, «Un an après l'accord de Skhirat, la dérive de la Libye paraît inexorable», Le Monde, 17 December 2016, http://www.lemonde.fr/idees/article/2016/12/17/un-an-apres-l-accord-de-skhirat-la-derive-de-la-libye-parait-inexorable_5050664_3232.html#3WF7pThxk19KpvE1.99.

controlled nearly all the Region of the Cyrenaica in eastern Libya, including two-thirds of the oil production. The task of protecting the critical facilities of Es Sider and Ras Lanuf fell into the hands of the Magharba Tribe that, until then, had formed part of the Jadran militias, but had since switched loyalties[138].

Similarly, in May 2017, with the help of the Egyptian Airforce, they took the bases of Hun and Wadran in the Central Region of Juffran, sealing off access to the south-west of the country. This cycle of military successes came to an end at the beginning of July 2017, when the forces of the LNA mopped up the last pockets of resistance of the Shura Council militias from Benghazi, bringing to an end a battle that had lasted for three years[139] and making General Hafter the arbiter of the situation[140].

From an energy perspective, a balance was struck between the two centres of power during this second phase, guaranteeing that neither government had access to the processes of commercialising the oil or the currency reserves, which were deposited abroad in the Libyan Foreign Bank[141]. Meanwhile, the Central Bank of Libya, which held approximately $90,000 million in currency reserves and received the revenue from the National Oil Corporation (NOC), remained neutral, continuing to pay the wages and consumption subsidies in the areas controlled by the two rival governments[142].

During this phase, the NOC's ability to obtain a higher price for oil also improved, because as a result of the delays in the deliveries owing to the interruptions to production and unplanned maintenance, the prices of Libyan oil had fallen when compared to other types of similar products. However, these problems were partially overcome as the clients, including the Chinese refineries, began to trust the NOC's ability to fulfil the terms of their supply contracts despite the war.

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138 HebsaSaleh,«Libyasuffers«catastrophicdamage»tokeyoilportfacility»,FinancialTimes, 18 June 2018. https://www.ft.com/content/6e447aa8-72c8-11e8-aa31-31da4279a601

139 Ayman Al-Warfalli, «Libya's Eastern Commander Declares Victory in Battle for Benghazi». Reuters, 5 June 2017, https://www.reuters.com/article/us-libya-security-benghazi-idUSKBN19Q2SK.

140 Emily Estelle y Min Young Park, «Fighting Forces in Libya: July 2017», AEI's Critical Threats Project, 28th July 2017, https://www.criticalthreats.org/analysis/fighting-forces-in-libya-july-2017.

141 «Libya´s political rivals compete for oil revenues», Jane´s Intelligence Review, 2nd December 2014.

142 David D Kirkpatrickapril, «One of Libya's Rival Governments Moves to Control Oil Revenue», The New York Times, 5th April 2015, http://www.nytimes.com/2015/04/06/world/middleeast/one-of-libyas-rival-governments-moves-to-control-oil-revenue.html.

3rd PHASE: New actors for a proxy warfare

The third phase, as from 2017, commenced with some notable positive effects for the Libyan oil sector. At the beginning of the year, some of the activity at the oil terminals in the Sirte Gulf resumed, after having been interrupted by the confrontations, while the Wintershall and Gazprom companies also resumed production from the As-Sarah Field, in the Sirte Basin. Furthermore, the drilling activity in the country also increased with new platforms coming into operation, while offshore the Italian company ENI put new wells into operation as part of its development of Bahr Essalam[143].

In early 2018, TOTAL announced its plan to purchase Marathon's shareholding in Waha, which operated in the Sirte Basin, thereby showing that the French firm was committing itself to the country. What is more, BP and ENI announced plans to start exploring in the Ghadames Basin, to the west of Libya, as part of a transaction that transferred to ENI, part of BP's interests in the concession. At that time, the NOC put great trust not only in political independence, but also in Libya's reliability and the reliability of the State-owned company.

The consequence was a spectacular recovery between June and October 2018, in which production almost doubled, coinciding with a critical situation for the global market in a context where the market reached 85 dollars/barrel ($/b) in October of that same year[144]. So, in the first half of 2018, for the first time since 2013, production reached one million barrels per day, while oil revenue nearly tripled from 4.8 billion dollars in 2017, to 14 billion dollars[145].

This was due to the combined effect of larger oil production and a recovery of international prices, which led to the country having a surplus, alleviating the liquidity crisis. Certain reforms were also carried out, aimed at improving living conditions and limiting opportunities for the militias. The reforms included introduc-

143 «APICORP_Energy_Research_V03_N14_2018.pdf».

144 David Sheppard, «Total chief executive says no shortage of supplies in oil market», Financial Times, 9 October 2018, https://www.ft.com/content/25b5d742-cbeb-11e8-b276-b9069bde0956

145 Fingar Courtney, «Libya enters fourth year of near investment blackout», Financial Times, 13 June 2018, https://www.ft.com/content/6c179166-06ff-461d-a539-e74cfccdb5c7?emailId=5f691e86c597cc0004aa2cf0&segmentId=7e94968a-a618-c46d-4d8b-6e2655e68320

ing taxes on transactions in foreign currency, which reduced the black-market rate by 25% and helped to close the gap between the black market and the official rate.

But although the economy was booming, things were very different on the military front. In June 2018, the Es Sider and Ras Lanuf Terminals were temporarily occupied by the Jadram militias, and their recovery a week later caused what the NOC described as «catastrophic damage»[146] as a result of the fighting, which destroyed at least two storage tanks; this reduced the capacity to 400,000 barrels, approximately half.

While all this was happening, the President of France, Emmanuel Macron, invited Hafter to Paris in July 2018, thereby giving him the political legitimacy he longed for but lacked, despite being the strongman of the country. This decision proved to be a turning point in the conflict in Libya by paving the way to the «final» battle for control over Tripoli. It amounted to a serious setback for the policy that had been pursued both by Italy and most of the European Union, aligned with the Government of Al Sarraj proposed by the UN in 2016. France thus regained the leadership it had lost in Libya, to the detriment of Italy, which until then had been dictating policy and had stated that «it wanted nothing to do with Hafter»[147].

With political backing from France and the new arms sent from Russia, Saudi Arabia and, particularly, from the United Arab Emirates, which broke the embargo imposed on Libya by the UN in 2011, Hafter managed to control the strategic Gulf of Sidra, heart of the Libyan oil industry, and intensified the offensives in Benghazi, capital of the east and the second city in the country, and neighbouring Derna, a stronghold of Jihadism in northern Africa[148].

Once these targets had been achieved, he began the campaign in the south in a strategic operation to reach the capital, his real target, avoiding the coastline, which was more direct, and logistically more reasonable, but which would have required to him to confront the powerful City-State of Misrata, which supported

[146] Heba Saleh, «East Libyan forces retake key oil ports hit by militia attack», Financial Times, 21 June 2018, https://www.ft.com/content/bbdff5e8-753a-11e8-b6ad-3823e4384287

[147] «News from France: The conflict in Libya: a silent war between Macron and Salvini», https://www.elconfidencial.com/mundo/2019-04-08/el-conflicto-en-Libya-la-guerra-silenciosa-entre-macron-y-salvini_1930010/.

[148] «A lot at stake in the battle for Derna - Elcano Blog», accessed 25 October 2020, https://blog.realinstitutoelcano.org/mucho-en-juego-en-la-batalla-de-derna/.

the Government in Tripoli. Apart from occupying the south of the country, the purpose of these manoeuvres was to control the Al Sharara and Al Fil Oilfields, which were essential for the economic survival of the Government in Tripoli[149]. Hafter achieved this objective in February 2019.

Once Hafter had done this, in April 2019, he launched a campaign to take Tripoli, backed by armed drones and missile systems supplied by the United Arab Emirates. Even so, six months later his forces were bogged down on the outskirts of Tripoli, which inspired Moscow to make a move that surprised the West, intervening and tipping the balance in the General's favour. Russia sent 2,000 Russian combatants, mainly mercenaries from the private group Wagner, linked to the Kremlin, to reinitiate the advance[150]. Backed from expert snipers, guided artillery and superior air support enabled the LNA to advance on several fronts around Tripoli in January 2020, and capture the strategic coastal city of Sirte.

Faced with the military developments and fearing that Russia might establish military bases in Libya[151], in September 2019 the German Government and Ghassan Salame, the UN Secretary General´s Special Envoy for Libya, initiated a consultation process that on 19th January 2020, culminated in the Berlin International Conference on Libya. The Conference brought together the Governments of Algeria, China, Egypt, France, Germany, Italy, Russia, Turkey, Republic of the Congo, the United Arab Emirates, the United Kingdom and the US, as well as the UN High Representatives, including the Secretary General of the UN, and the Special Representative for Libya, the African Union, the European Union and the Arab League. The Conference tried to find a consensus among the interested Member States regarding the Libyan Crisis and guarantee an international umbrella to protect talks in Libya about the country's future[152]. However, the Conference was a failure.

[149] «Hafter announces control over the Al Fil Oilfield, the second largest in Southen Libya», https://www.lavanguardia.com/internacional/20190221/46616054463/hafter-anuncia-control-del-campo-de-crudo-al-fil-segundo-mas-grande-del-sur.html.

[150] «AFRICOM: «2,000 Wagner mercenaries are fighting for Haftar in Libya»«, https://www.trt.net.tr/espanol/mundo/2020/06/16/africom-2-000-mercenarios-wagner-estan-luchando-por-haftar-en-Libya-1437197.

[151] Declan Walsh, «Libyan Rivals Call for Peace Talks. It May Be Wishful Thinking», *The New York Times*, 22ndSeptember 2020, sec. World, https://www.nytimes.com/2020/08/21/world/middleeast/libya-ceasefire.html.

[152] UNSMIL, «Berlin International Conference on Libya», 19 January 2020. https://unsmil.unmissions.org/berlin-international-conference-libya-19-january-2020

Determined «to teach General Hafter the lesson he deserved»[153], in January 2020, Turkey deployed its own drones and between 400 and 2,000 Syrian mercenaries, in support of Tripoli's Government of National Accord (GNA)[154]. In June, the GNA's troops, backed by Turkey forced Hafter's combatants and their Russian allies to lift the siege and retreat hundreds of kilometres from Tripoli back to Sirte, on the Mediterranean Coast[155].

In September 2020, after months of stagnation in Sirte, German and US diplomacy put pressure on both sides to accept a UN proposal to establish a demilitarised zone around the city, as a first step towards more extensive peace talks. The initiative was supported by Egypt and Turkey, even though in other aspects they are regional rivals that oppose each other on many issues.

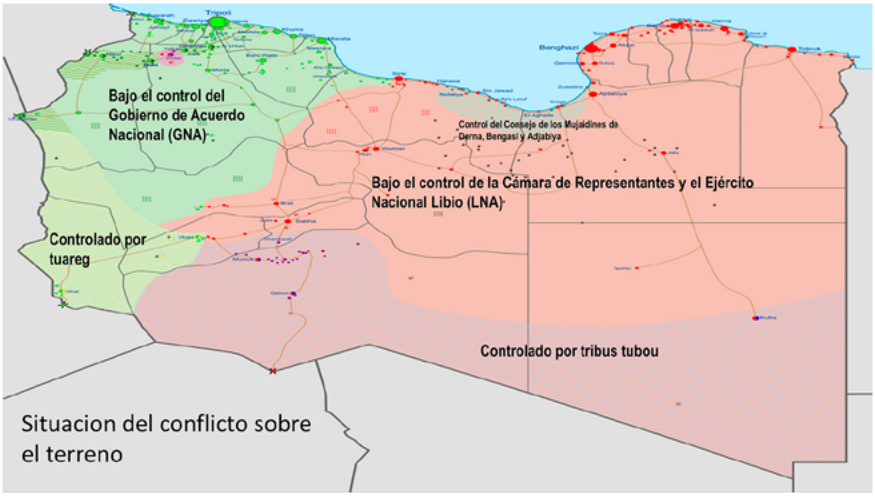


Figure 11. Conflict situation in December 2020. Source: Own research using Ali Zifan (vectorised map) - Libyan Civil War detailed map, https://commons.wikimedia.org/w/index.php?curid=47087538.

153 «Erdogan accuses Hafter of ethnic cleansing and threats «to teach him a lesson»«, https://www.lavanguardia.com/internacional/20200114/472897346708/erdogan-acusa-a-hafter-de-limpieza-etnica-y-amenaza-con-darle-una-leccion.html.

154 «As Libya Descends Into Chaos, Foreign Powers Look for a Way Out - The New York Times», https://www.nytimes.com/2020/01/18/world/middleeast/libya-war-hifter-russia.html.

155 Declan Walsh, «Waves of Russian and Emirati Flights Fuel Libyan War, U.N. Finds», *The New York Times*, 3rd September 2020, sec. World, https://www.nytimes.com/2020/09/03/world/middleeast/libya-russia-emirates-mercenaries.html.

Conditional support for the demilitarisation of Sirte is part of a broader Turkish strategy to control the resources, where troop deployment is subject to the Maritime Boundary Agreement signed in December 2019 with the Tripoli Government recognised by the UN. The Agreement establishes the frontier between their exclusive economic zones along a boundary running 100 kilometres to the south of the Greek island of Crete, which is of great importance when it comes to finding and controlling hydrocarbons in the Western Mediterranean. The purpose of the agreement is to block any oil pipeline that crosses the Mediterranean[156].

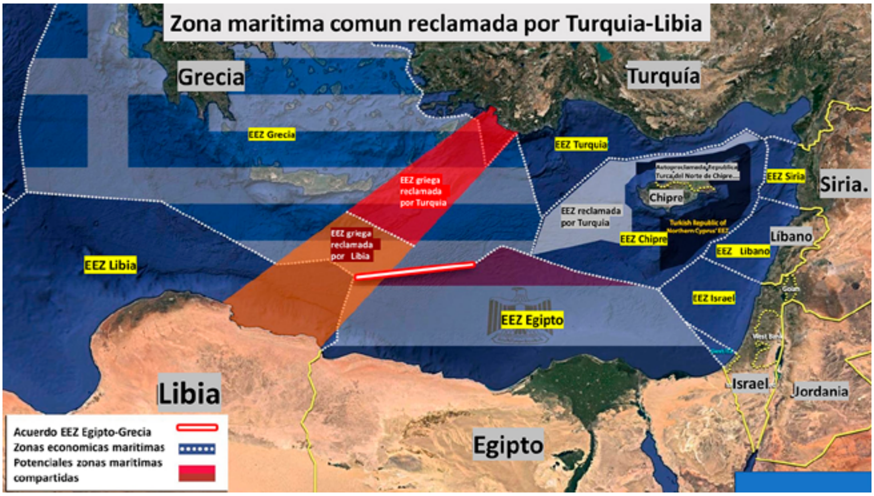


Figure 12. Maritime zones claimed by Turkey and Libya.
Source: own research from various sources.

This Memorandum of Understanding was rejected not only by the Greek, Cypriot and Egyptian Governments, but also by the European Union[157], because they all considered that it infringed upon the sovereign rights of third countries, that it did not comply with the Laws of the Sea and had no legal consequences for Third-Party States[158]. Turkey also questioned Cyprus's right to

[156] «Turkey fuels regional power game over Mediterranean gas reserves | Financial Times», https://www.ft.com/content/69a222d4-b37c-4e7e-86dc-4f96b226416d.

[157] «EU leaders consider the Turkish-Libyan Agreement affecting Greece and Cyprus to be illegal», https://www.lavanguardia.com/politica/20191213/472197684810/lideres-ue-ven-ilegal-pacto-maritimo-turco-libio-que-afecta-a-grecia-y-chipre.html.

[158] Article 57 of the United Nations Convention on the Law of the Sea situates the maximum width of an EEZ at 200 nautical miles (370 kilometres) as from the coast that serves to calculate the territorial waters. It would only be possible to form the Turkish

explore in the seas surrounding the island, claiming that the Nicosia Administration did not represent the Turkish Cypriots.

However, Turkey's position is much more than a mere struggle for resources. It is a risky geopolitical game that involves trying to restore the influence of the Ottoman Empire, despite the serious consequences that this has for the regional balance[159]. Erdogan and some of his allies would be under the impression that Turkey was recovering its importance in the eyes of its Western allies, in such a way that the more assertive the role it plays in the region, the more worthy and impossible to ignore it will be for the West[160].

The result is a confrontation between Turkey, Libya (GNC) and the north of Cyprus and Italy on the one hand, and Cyprus, Greece, Egypt and Israel, plus the United Arab Emirates and France, on the other. However, there is no genuine economic need to access the energy resources in the zones questioned to the north of Libya and the south of Turkey, given that the resources in question are too deep for any significant mining operations. Even when oil was at 90 $/bbl, it was not profitable to drill down to depths greater than 2,400 metres.

Egypt's President Abdel Fattah al Sissi, who was hitherto a firm supporter of General Hafter, appears to have changed his position since the failure of the offensive against Tripoli, by openly supporting Aguila Saleh Issa who heads the Parliament with its headquarters in Tobruk in the east of the country[161]. Furthermore, Al Sissi has threatened a military intervention in neighbouring Libya if the forces backed by Turkey capture Sirte, a strategic port and gateway to important oil terminals, or the inland air base of Juffra, as he considers both of them to be a «red line» not to be overstepped[162].

Meanwhile, the production and export of Libyan oil in 2020 have followed the vicissitudes of the war. In January, most of Libya's oil production was suspended by a blockade against exports in the

EEZ if the Turkish aim were accepted that the Greek islands and islets, many of which lie close to the coast of Turkey, could not be used to define an EEZ.

159 «How Turkey is trying to recover the influence of the Ottoman Empire and what consequences this has for the international balance - BBC World News», https://www.bbc.com/mundo/noticias-internacional-54418272.accedido 9 de diciembre de 2020, https://www.bbc.com/mundo/noticias-internacional-54418272.

160 «Turkey fuels regional power game over Mediterranean gas reserves | Financial Times».

161 «Waves of Russian and Emirati Flights Fuel Libyan War, U.N. Finds - The New York Times», https://www.nytimes.com/2020/09/03/world/middleeast/libya-russia-emirates-mercenaries.html.

162 «Egypt threatens military action in Libya if Turkish-backed forces seize Sirte | Financial Times», https://www.ft.com/content/e6aa87b0-5e0b-477f-9b89-693f31c63919.

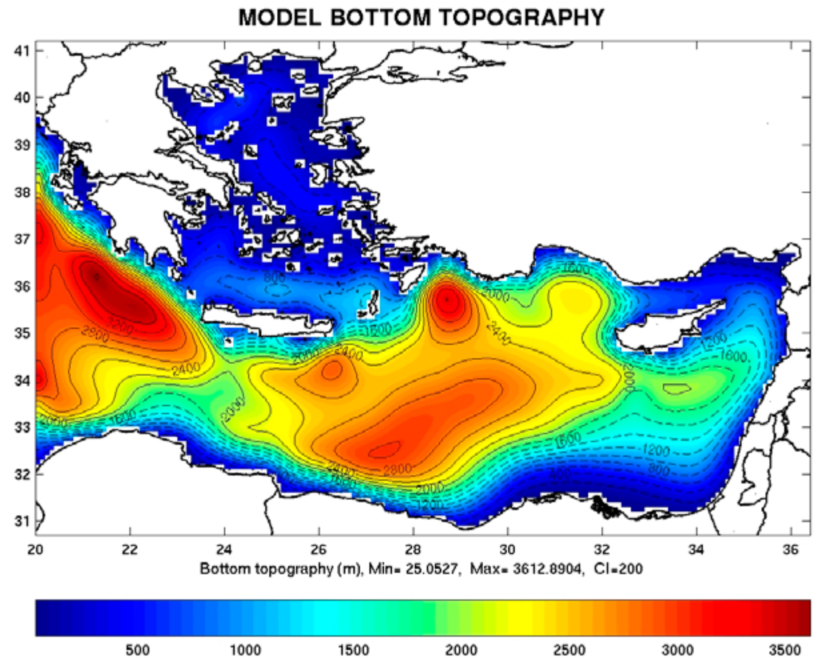


Figure 13. Seabed topography in the Eastern Mediterranean
Source: Triantafyllou, George & Gerasimos, Korres & Hoteit, Ibrahim & Petihakis, G. & Banks, Andrew. (2007). Assimilation of ocean colour data into a Biogeochemical Flux Model of the Eastern Mediterranean Sea. Ocean Science. 3. 410. 10.5194/os-3-397-2007.

Gulf of Sirte imposed by General Hafter's forces. Libyan production decreased by more than 1 million bbl/d, or approximately 1% of the world demand, falling to less than 200,000 bbl/d, while at the same time the country's National Oil Corporation found itself having to close down production owing to a lack of storage facilities[163].

The economic consequences of stopping oil production and exports were dramatic. In just the first eighteen days of January, the country's economy lost more than $5,000 million due to the interruptions to the oil supply from the eastern oilfields in the oil crescent, which was added to the over $100,000 million lost since 2016. With the Central Bank reserves standing at the lowest level in their history, the country was fraught with serious problems when it came to paying the salaries of the Government employees and the basic amounts required to pay for food, health and education[164].

163 «OPEC eyes further oil supply cuts to counter coronavirus rout | Financial Times», https://www.ft.com/content/cc0de784-40fb-11ea-bdb5-169ba7be433d.

164 «Libyan oil production comes to halt, affects economy», https://www.aa.com.tr/en/middle-east/libya-oil-production-comes-to-halt-affects-economy-/1860775.

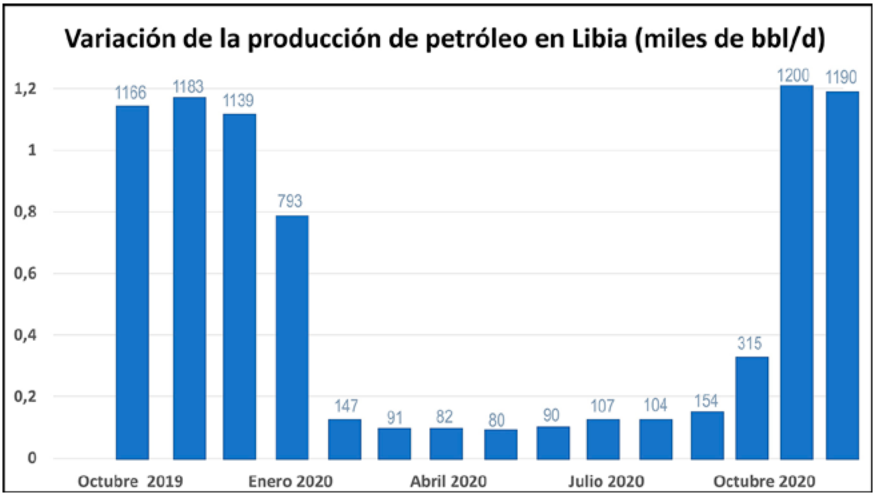


Figure 14. Variations in oil production in Libya in 2019-2020. Source: tradingeconomics.com/organization of the petroleum exporting countries.

Even so, any interruption to production in Libya cannot last indefinitely, because both sides rely on oil revenue to subsist, so it is hardly surprising that, a few months later, on 18 September 2020, General Hafter announced an end to the blockade. A few days later, on 23 October the Government and the House of Representatives, the leaders of the confrontation, signed an immediate «national and permanent» ceasefire agreement, thanks to UN mediation[165].

The consequences of the improved situation can already be felt. Production tripled rapidly in December 2020[166], reaching about 1,200,000 bbl/d, coinciding with the resumption of production in another oilfield in the country. This has brought about a new oversupply problem for the OPEC countries, which were trying to rebalance the market, and endeavouring to do so in very adverse circumstances, owing to the impact of COVID-19 on the world economy.

The Sarir oilfield, with an output of 200,000 bbl/d has resumed its operations, as have the Libyan oil terminals at Hariga, Brega

165 «Declaration of the High Representative on behalf of the EU concerning the announcement of a ceasefire agreement in Libya - Consilium», https://www.consilium.Europe.eu/es/press/press-releases/2020/10/25/declaration-by-the-high-representative-on-behalf-of-the-eu-on-the-announcement-of-a-ceasefire-agreement-in-libya/#.

166 «Libya's oil production recovers past 1M barrel a day», AP, https://apnews.com/article/turkey-africa-libya-middle-east-tripoli-a21bb93b6e866af684588ef5e9786a63

and Zueitina. The Sharara oilfield (300.000 bbl/d), the largest in Libya, was also opened in October 2020, as a result of a «Gentlemen's Agreement» between the NOC and the militia known as the Petroleum Facilities Guard. The nearby El Feel oilfield, with a capacity of 70,000 bbl/d and the oil terminal at Zawiya, which normally exports crude oil from Sharara[167] were also opened. According to the Libyan National Oil Corporation (NOC), these oilfields will require major repairs before they can resume pumping at full capacity, so a complete return to supply of one million bpd from Libya is by no means imminent and will probably take some time, which the OPEC views with a sigh of relief[168].

It is estimated that in the future, if the truce holds, crude oil production in Libya could reach 1,300,000 bbl/d over the coming 12 months. In the long term, Libyan crude oil production is expected to reach around 1,200,000 bbl/d in 2021 and 1,150,000 bbl/d in 2022, according to different econometric models[169]. Nevertheless, that will ultimately depend on whether the terms of the ceasefire are respected; these include the exit of all the foreign combatants and mercenaries in Libya, as well as total and unconditional compliance with the Security Council's arms embargo that has been in force since the conflict broke out.

Conclusions

Where Algeria is concerned, the first conclusion to be extracted is that the country will still be a natural gas and oil producer for the next 20 years, in an international environment that suggest that by 2040, oil and gas will still account for at least 40% of the total world energy. Likewise, it would seem clear that Europe, especially Southern Europe, will still be the main market for Algerian natural gas exports, at least until 2030, as it is being confirmed by the recent series of contract renewals for periods ranging from five to ten years, even though most of them are for lower export volumes than those included in the original contracts.

Yet it is highly likely that after 2030, Algeria's role as a gas exporter will be significantly reduced and it will be difficult for

167 «Libya's Oil Crescent Gets Back to Work as Sarir Field Opens - Bloomberg», https://www.bloomberg.com/news/articles/2020-09-30/libya-s-oil-crescent-gets-back-to-business-as-sarir-field-opens.

168 «Libyan Oil Production Hits 300,000 Bpd As Another Oilfield Comes», https://oglinks.news/opec/news/libya-oil-production-hits-300-000-bpd-another-oilfield-comes.

169 https://tradingeconomics.com/libya/crude-oil-production

the country to regain the comfortable position it occupied before, when it exported gas at around 60 Bcm per year, in view of the major decline its exports have undergone in the last two decades. What is more, Algerian gas exports will have to compete with new or already existing exporters such as Qatar, Nigeria, the US, Australia and even Mozambique.

Even in a favourable international scenario, it is difficult to imagine that the balance of natural gas in Algeria could undergo significant improvements in supply and demand before 2030 and that the potential exports of natural gas might undergo a substantial increase. The existing oil fields are maturing, and without new investments, production will soon begin to decrease at a considerable rate. The economic situation is also encouraging many skilled and qualified Algerian workers to seek alternatives abroad. Therefore, Algeria will probably have to make do with a much lower potential export volume until 2030.

What is more, Algeria is unlikely to opt for extracting unconventional gas at a time of low prices, a supply surplus and strong opposition from many sectors of the population. It is rather unrealistic to think that Algeria's potential unconventional gas resources could have a significant impact on the country's natural gas supply situation before the end of the next decade, even if they are checked and developed. However, it would be possible to release more gas for export if Algeria were to invest in solar energy to cater for its growing electricity demand, but nonetheless gas will have to compete in the already overcrowded European market.

Although increasing the export capacity via gas pipeline might improve gas export opportunities, especially if relations between Russia and Europe deteriorate, Algeria will have to face up to growing competition from the new LNG exporting powers that offer more flexible contracts where price setting is concerned. In this sense, Algeria must regard the renewed gas export contracts signed in recent years in a positive light, because this will enable it to carry on playing a major role in exporting gas to Southern Europe. At the same time, the reduction in the volumes of gas exports contracted will make it possible to adapt the limited availability of gas supplies from Algeria.

Another factor that must not be forgotten is the security problems in a country that shares 1,376 Km of desert frontier with Mali, 956 Km with Niger and 982 Km with Libya, where war and the threat of terrorism are problems that are still unresolved.

It would appear to be clear that Algeria must liberalise the economy and promote a genuine business climate, repealing laws and regulations that discourage initiative. To date, every attempt to bring about reform has become bogged down because neither the role of the Administration nor the banking nor taxation system have been really questioned in a political environment in which the power struggle confronts those in favour of liberalism and the nostalgic supporters of socialism[170].

However, before taking any economic measures, President Abdelmadjid Tebboune must solve a thorny question that could cause social unrest in the short term, i.e. how to reorganise the production system inherited from a parasitic rent economy at oil prices of over 80 dollars a barrel. Although the current political climate prevalent in Algeria is not conducive to reforms in the short term, such reforms are inevitable and must be implemented earlier rather than later to ensure that the country is not subjected to increasingly severe financial restrictions and social disturbances.

Preparing and applying suitable and extensive reforms in the energy sector will largely depend on how the political transition evolves in the country over the next few years, and how to approach the fight against rampant corruption that lies behind the protests staged by an extensive part of Algerian society in favour of greater democracy. All of this could mean accepting the dismissal of tens of thousands of employees from a Public Administration with an inflated work force, basically, people who are employed by the two main State-owned firms in the country: Sonatrach and Sonelgaz. As the new President, Abdelmadjid Tebboune, has already stated, it would be a case of «separating money from politics», to concentrate on improving the economic situation and the standard of living for the country's inhabitants.

If the reforms fail – which means failing to detain the decline in oil and gas production, failing to attract new foreign investment and failing to develop new markets, especially for natural gas – or if the reforms are not implemented, Algeria could embark on a downhill spiral of decline, with a decrease in revenue, a speeding up of the «brain drain» and greater security risks, all of which could lead to civil unrest, with serious consequences for the Region and for Europe.

[170] «Le libéralisme sauvage a crucifié les valeurs humaines | El Watan», https://www.elwatan.com/edition/contributions/le-liberalisme-sauvage-a-crucifie-les-valeurs-humaines-27/11/2018.

In the case of Spain, both Sonatrach and the Algerian Government should review the contracts and the way to negotiate them, in order to recover the share of the Spanish market and prevent the potential catastrophe of losing the entire European market, which would have a major effect on the country's financial income. It must be pointed out that the rival countries are beginning to apply more aggressive trading strategies to capture most of the foreign markets, starting with Spain.

Strategic logic suggests that it is in Algeria's interest to strengthen the shortest and cheapest route for conveying gas to Spain, which is currently limited by the absence of infrastructures to enable gas to reach the «heart» of Europe, thereby allowing Algeria to make inroads into a market that has so far resisted open competition because of the power held by the State monopolies.

This strategic course of action converges with both the Spanish and European Union ones, which are in favour of an energy interconnection for the whole continent, for Eastern, Northern and Southern Europe, which make it possible to constitute a still distant Energy Union in which the supply sources are diversified.

To achieve this, it would be necessary to complete the Midcat gas pipeline, which would connect Catalonia with France and would permit the extension of the Medgaz, which would certainly be an incentive to increasing the production and demand for Algerian gas. If this gas pipeline were to be completed, across the Pyrenees, Spain would be less exposed to any interruptions to its supply from northern Africa, and would also be able to supply Algerian gas to the EU, with numerous benefits as a transit country[171]. At the same time, Algeria's position on the world gas market would improve. For this to happen, it would first be necessary to overcome the French Government's continued reluctance to go ahead with this project, bearing in mind that the French President, Macron, stated at the Lisbon Summit in July 2018 that «we are not going to construct gas pipelines unless consumption is considerable»[172].

[171] «Energy Security: concept, scenarios and implications for Spain and the EU (DT) - Elcano», 11, http://www.realinstitutoelcano.org/wps/portal/rielcano_es/contenido?WCM_GLOBAL_CONTEXT=/elcano/elcano_es/zonas_es/dt33-2006.

[172] «Macron halts (for the time being) the gas pipeline STEP and prefers to focus on electrical interconnection – El Periodico de la Energía | El Periodico de la Energía with daily information about electricity, wind energy, renewables, oil & gas, markets and energy legislation».

An agenda of reforms for Algeria deserves the European Union's active support, given Algeria's potential not only for providing Europe with low-cost energy, but also, and perhaps more importantly, in view of Europe's need to help to stabilise a country that could otherwise easily become the source of a large number of economic immigrants and major security problems. As Charles Michel, President of the European Council, stated, Europe must pay more attention to Africa and look at the continent, including Algeria, «in a new light». But a quick glance is not enough. What is required is a substantial change in European energy policy that, instead of looking in other directions, should recognise the importance of the south, so it can make the most of better energy opportunities and reduce the risks that affect its security.

In the case of Libya, the agreement reached on 23 October 2020 between the Government and the House of Representatives envisaged the exit of foreign troops, which has been seen by the Parties and most foreign powers as the beginning of a return to peace. Yet it is difficult to imagine that the foreign stakeholders are going to give up their interests in the African country with the largest oil reserves and that all the foreign forces in the country and the foreign mercenaries are actually going to leave, in circumstances where Turkey has consolidated its presence and Russia is exerting considerable influence with its mercenaries.

In fact, the Agreement reached on 23 October 2020 between the Government and the House of Representatives has not been well received by Turkey, whose President Erdogan «does not think it is trustworthy»[173] because he believes that it should have been agreed to by the Leader of the National Government, supported by the international community (especially by Turkey and Qatar), and the authorities in the East, whose best-known figure is General Jalifa Hafter, who is being supported by Russia, Egypt and the United Arab Emirates.

However, there are signs of hope. The Libya 5+5 Committee (five representatives on each side) has made major progress, by reopening the country's land and air routes that had been closed since April 2019. Another success has been the decision to increase and share oil production as long as the commanders, in the words of the Representative of the Secretary General

[173] «Erdogan says he does not think the Libyan ceasefire signed in Geneva is reliable», https://www.lavanguardia.com/politica/20201023/484236625140/erdogan-dice-que-no-parece-fiable-el-alto-el-fuego-libio-firmado-en-ginebra.html.

of the United Nations, Stephanie Williams, «work together with the Representative of the NOC to achieve a restructuring of the Petroleum Facility Guard [174]» in view of the fact that one of the main reasons for exports being stopped in recent years has been the fact that the Guard tends to change sides depending on how the war situation develops.

In any case, increases in Libyan production will depend on the reopening of the oil-rich Sirte Basin and the oilfields that supply the crucial export terminals of Ras Lanuf and Es Sider, in the Libyan «oil crescent». Resuming activities in the Sirte Basin could lead to an increase in Libyan oil production by a further 900,000 bbl/d[175]. Nevertheless, this zone is still the epicentre of the civil conflict in Libya and at present its energy facilities are controlled by the Army of Hafter and Wagner, the Russian mercenary group. It will be difficult for the oil situation to get back to normal, especially at the «oil crescent» facilities, until the over 20,000 foreign forces and mercenaries in Libya have left, given that they help the warring factions, not only the National Unity Government in Tripoli backed by the United Nations, but also the strongman Khalifa Hafter, in the east of the country.

A greater cause for concern is the fact that even if Libya succeeds in successfully managing its political differences and puts an end to the civil war, the damage to the infrastructures has already been done and it will be difficult to undo it in the short term. The cost of reconstruction has been estimated as ranging from $200,000 to $480,000 million over a period of ten years[176]. It is a huge amount that Libya would find it difficult to obtain, unless a major foreign financial operation were to take place. Yet even if an agreement to that effect were to be reached, it would first be necessary to put a stop to the spiral of violence, which would be difficult to achieve in the short term.

All in all, ten years after the Revolution that brought such great expectations for Libya's population and the international community, the way hydrocarbon production and exports evolve in the country keeps conditioned by a policy that is still very vague

[174] «The conflicting sides in Libya signed a «permanent» ceasefire full of challenges», https://www.france24.com/es/%C3%A1frica/20201023-Libya-acuerdo-alto-fuego-gobierno-parlamento-ginebra.

[175] «What Libya's oil deal means for the global market – Investors News Blog», http://investorsnewsblog.com/2020/09/22/what-libyas-oil-deal-means-for-the-global-market/.

[176] «Libya: crude implosion | European Union Institute for Security Studies», https://www.iss.Europe.eu/content/libya-crude-implosion.

and by the serious and unsolved structural problems that the country is afflicted by. Obtaining a legitimate and honest political agreement that will put an end to the conflict is still the major challenge in the short term and the only way to get sustainable flows of hydrocarbons for export[177]. If this is not achieved, the country will continue to slide deeper into a low-intensity civil war, a situation that could last for years, even decades, and this would end up by confirming Libya as being the epitome of a failed State.

[177] «What Libya's oil deal means for the global market – Investors News Blog», http://investorsnewsblog.com/2020/09/22/what-libyas-oil-deal-means-for-the-global-market/. M

Chapter five

Rare earths, a key piece in the energy puzzle

Ricardo Prego Reboredo

«A nation in which sciences and applied arts languish will be overtaken by rival nations and will gradually lose its ability to compete; their trade, their wealth, will pass into the hands of foreigners ...»

Antoine Lavoisier (1743-1794)

Abstract

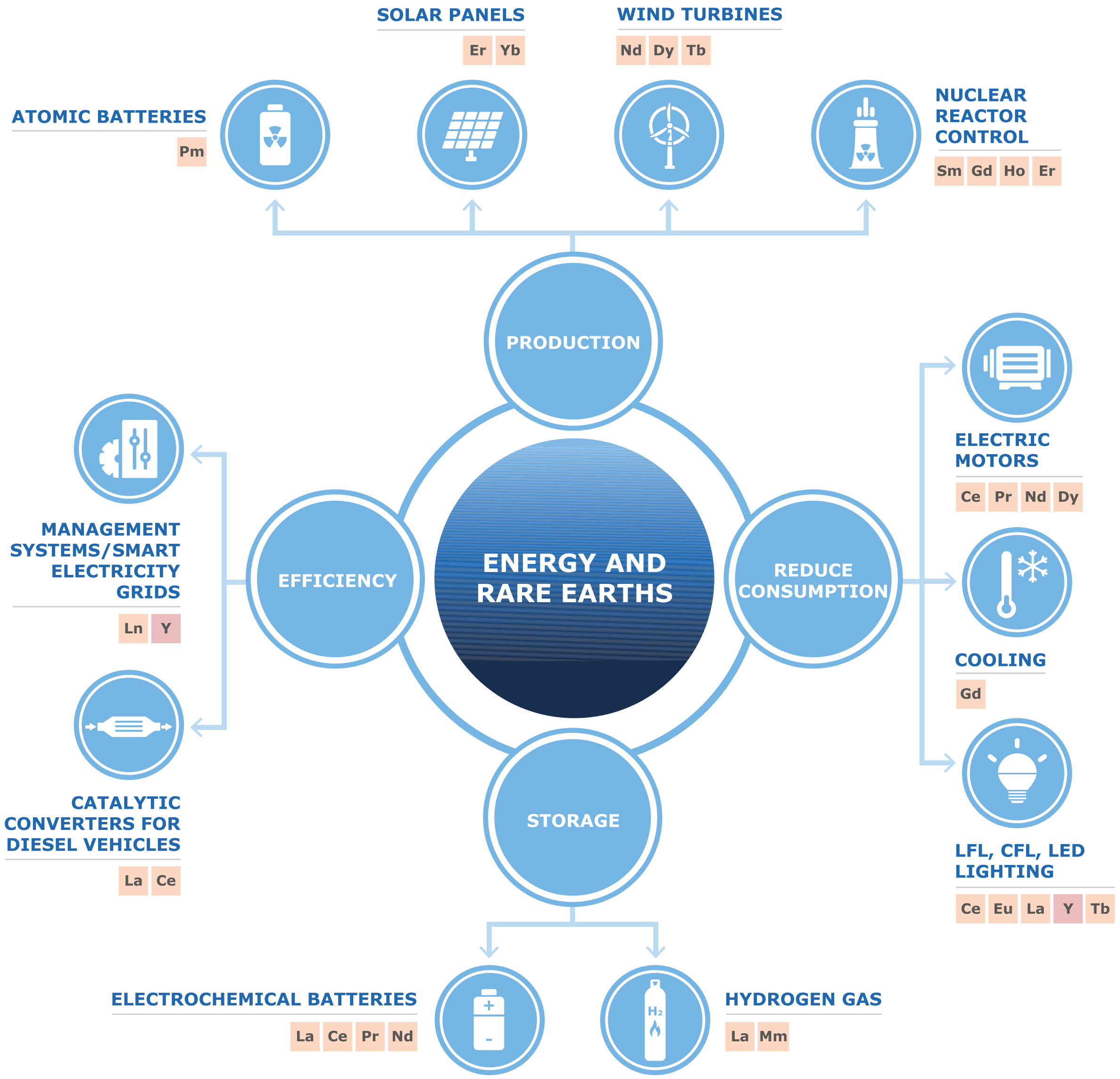
Today's high technology relies on rare earth elements and we would go back to 1960 if they did not exist. These elements are strategically important to the military, critical to industry and key to the management of energy, by way of: consumption (lighting, magnets, vehicles), storage (batteries, hydrogen storage) and production (wind turbines, photovoltaic panels, nuclear reactors). Doubts arise about using these elements for green technologies and the energy transition due to the contamination that results from their mining. Hence, the complete extraction-use cycle must be considered. Scientific publications and author's affiliation are dominated by Chinese experts. Governments must work closely with their scientific institutions and the technology industry.

China depressed prices and achieved a virtual monopoly (97% of world production in 2010, while Western mining culture languished) by exploiting its Baiyun-ebo mine, the largest in production/reserves on the planet. China wants to become the world leader in the energy and digital transition and to have a shareholding in foreign mines by 2025. The 2009-2013 crisis affected supply and prices. The answer was to diversify sources and support companies. The exploitation of new mines began, others were reopened and the search for reserves across the planet was promoted, including underwater mining. Recycling of these rare earth elements was also actively encouraged. In 2019, there were eleven countries in an expanding mining market where Chinese production accounts for 62% of the total worldwide production.

Keywords

Energy, rare earths, clean technologies, critical elements, China.

ENERGY AND RARE EARTHS



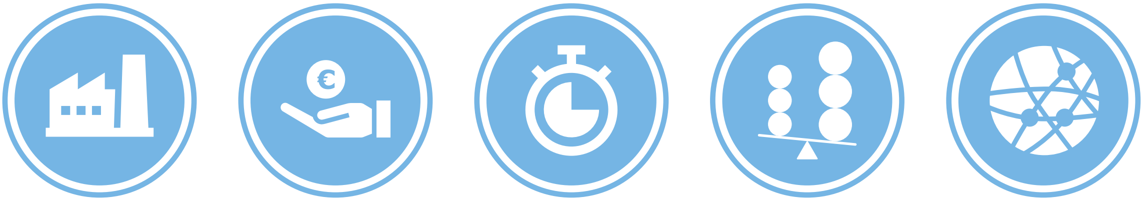
RARE EARTHS ELEMENTS:

Lanthanum (La), Cerium (Ce), Praseodymium (Pr), Neodymium (Nd), Promethium (Pm), Samarium (Sm), Europium (Eu), Gadolinium (Gd), Terbium (Tb), Dysprosium (Dy), Holmium (Ho), Erbium (Er), Thulium (Tm), Ytterbium (Yb), Lutetium (Lu), Yttrium (Y).
Mischmetal (Mm): Cerium (45-50%), Lanthanum (25%), Neodimium (15-20%) and Praseodymium (5%). Lanthanids (Ln: from La to Lu).

CRITICAL ELEMENTS AND RARE EARTHS

CRITICAL ELEMENTS

THOSE WHOSE SHORTAGE WOULD DAMAGE A COUNTRY'S ECONOMY AS THEY ARE ESSENTIAL FOR ITS INDUSTRY



TYPE OF INDUSTRY | **PRICE** | **TIME** | **PRODUCTION/ CONSUMPTION BALANCE** | **GEOPOLITICS**

RARE EARTHS

Sc Scandium	**Y** Yttrium	**La** Lanthanum	**Ce** Cerium	**Pr** Praseodymium	**Nd** Neodymium
Pm Promethium	**Sm** Samarium	**Eu** Europium	**Gd** Gadolinium	**Tb** Terbium	
Dy Dysprosium	**Ho** Holmium	**Er** Erbium	**Tm** Thulium	**Yb** Ytterbium	**Lu** Lutetium

RARE EARTH ELEMENTS:

CRITICALITY: REPLACEABLE IN DEVICES — 100% | 50% | 25% | 0%

The Age of Rare Earths

The short history regarding the discovery of rare earth elements began in 1787, during the great Chemistry Revolution set in motion mainly by Lavoisier, Mendeleiev and Mosley to classify the chemical elements. They were originally called *earths* because they could not be separated from their oxides using the technological expertise of the 18th Century. All that could be said is that those «earths» were oxides of CPSL metals, and their identification was accepted without it being possible to separate them from their oxides. «Rare earths» are not actually «earths», the original name has become archaic in Chemistry even if it usually turns up[1], but neither are they rare, i.e., scarce or difficult to find. For example, they are more abundant than mercury, gold or silver in the Earth's crust (see Figure 1). They were originally given

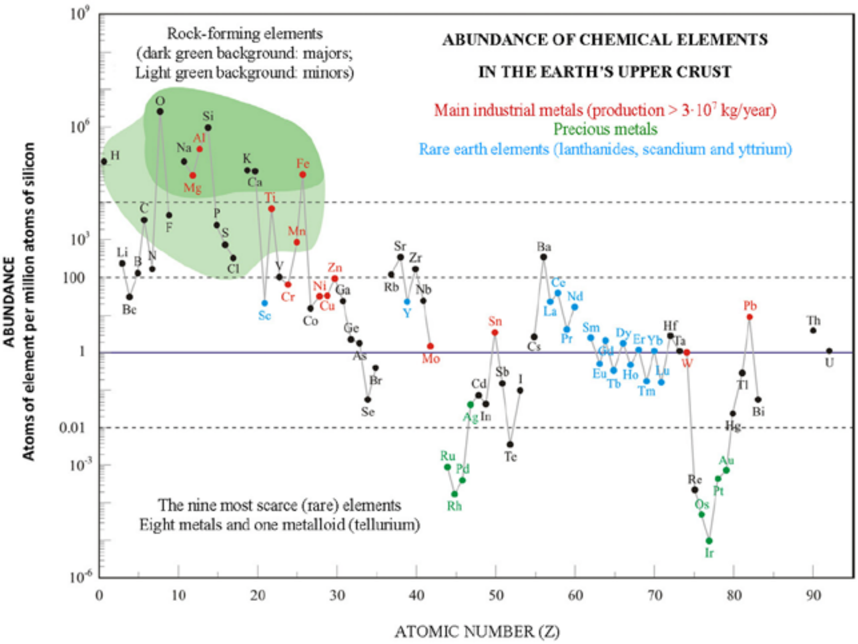


Figure 1. Relative abundance of the chemical elements in the Earth's upper continental crust as a function of the atomic number. The rare earth elements are indicated in blue (adapted from E. Generalic, https://www.periodni.com/rare_earth_elements.html).

[1] This leads to absurd usage, e.g., the acronym REO (*Rare Earth Oxides*) frequently used to refer to the oxides of elements in the rare earths when *earth* and *oxide* are synonyms.

that name because the minerals containing them were difficult to find and, what was more, it was necessary to look for them in Sweden. The discovery[2] all started with two minerals: gadolinite (sometimes known as ytterbite), in the Ytterby Mine, and cerite in the Bastnäs Mine. Both minerals are the starting point for the discovery of the other rare earth elements, grouped into two families[3], The Ceric Family and the Yttric Family (Table 1).

Year	Metal (symbol)	Author (country)
Gadolinite mineral (or ytterbite)		
1794	yttrium (Y)	J. Gadolin (Sweden)
1843	erbium (Er)	C. Mosander (Sweden)
1843	terbium (Tb)	C. Mosander (Sweden)
1878	ytterbium (Yb)	J.C. de Marignac (Switzerland)
1879	thulium (Tm)	P.T. Cleve (Sweden)
1879	scandium (Sc)	L. Nilson (Sweden)
1879	holmium (Ho)	P.T. Cleve (Sweden)
1886	dysprosium (Dy)	P.E. Lecoq de Boisbaudran (France)
1907	lutetium (Lu)	G. Urbain (France) & C. Auer von Welsbach (Austria)
Cerite mineral		
1803	cerium (Ce)	J.J. Bercelius & W. Hisinger (Sweden); M. Klaproth (Germany)
1839	lanthanum (La)	C. Mosander (Sweden)
1879	samarium (Sm)	P.E. Lecoq de Boisbaudran (France)
1885	praseodymium (Pr)	C. Auer von Welsbach (Austria)
1885	neodymium (Nd)	C. Auer von Welsbach (Austria)
1886	gadolinium (Ga)	J.C. de Marignac (Switzerland) & P.E. Lecoq de Boisbaudran (France)
1898	europium (Eu)	E. Demarçay (France)
Disintegration of uranium		
1945	promethium (Pm)	J. Marinsky, L. Glendenin & C. Coryell (USA)

Table 1. Discovery of the rare earth elements.
Based on Krebs, R.E., 2006. The history and use of our Earth's chemical elements (2nd Ed.). Greenwood Press.

[2] For details refer to: PREGO, R., «Las Tierras Raras», Editorial Catarata, Madrid, pages 13-38, 2019.

[3] Rare earth elements are generally grouped into light (LREEs: *Light Rare Earth Elements*) and heavy (HREEs: *Heavy Rare Earth Elements*). Although, the IUPAC classifies seven as being light: from lanthanum to gadolinium (promethium is not considered), which coincides with the Cerium family, and a further seven as being heavy: from terbium to lutetium, they would be the yttrics, There are other different classifications, and one more division is even made (MREEs: *Middle Rare Earth Elements*) or yttrium is included among the heavy ones. All of this causes confusion it being very convenient for this to be explained in the text about the elements.

Studying rare earths was originally limited, because scientists only had available small amounts of samples for research purposes. This shortcoming ended in 1879 with the finding of samarskite deposits in the US; this oxide put an end to the shortage and high cost in chemistry laboratories. Rare earths kept their name, but from that point on they were no longer «rare». The discovery and separation of these elements was successful between 1794 (yttrium) and 1907 (lutetium), the only exception being promethium (1945), which was found with the making of the first atomic bomb. It was a great adventure for the experimental chemistry of a few scientists who had «romantic» leanings and sought new chemical elements in nature, spending many hours in their laboratories. In the words of George de Hevesy (1885-1966), Nobel Prize for Chemistry (1943): «To have discovered and isolated nearly all of the rare earths without further theoretical guidance, in spite of their great similarity and the great rarity of some of these, is one of the most brilliant accomplishments that experimental chemistry has ever produced»[4].

So, step by step, and on and off, the 16 elements that appear in Table 1 were identified. Those, together with promethium (61Pr), which was obtained in a different way, are rare earths' 17 components: scandium (21Sc), yttrium (39Y), lanthanum (57La), cerium (58Ce), praseodymium (59Pr), neodymium (60Nd), samarium (62Sm), europium (63Eu), gadolinium (64Gd), terbium (65Tb), dysprosium (66Dy), holmium (67Ho), erbium (68Er), thulium (69Tm), iterbium (70Yb) and lutetium (71Lu). The number that appears before the chemical symbol for each element is the atomic number (acronym Z), i.e. the number of protons in its nucleus. As the atom is electronically neutral, these positive charges are made up for with an equal number of electrons located in different orbitals surrounding the nucleus. From lanthanum to lutetium, there is a one proton and one electron increase from one element to the next, forming the group known as lanthanides. In nature, they do not exist in a native state but as ions, normally with three positive charges. The ionic radii of lanthanides are all very similar. Yttrium and scandium, which are also trivalent cations, are added to this set; given that they usually appear mixed in the same deposits with lanthanides. These similarities between different lanthanides, because of their f electronic orbitals, their trivalence and ionic radius, make them

[4] HEVESY, G., «The discovery and properties of Hafnium», Chemical Reviews, 2: 1-41, 1925.

behave in a chemically similar way, so they appear in the same minerals, albeit in different proportions, which conditions their separation and, thus, did condition their discovery.

Carl Auer von Welsbach[5] was among the one hundred scientists who participated in this task undertaken in Europe (Table 1). He was not only a good chemist -he discovered praseodymium and neodymium-, but also a brilliant businessman. Auer set out on a successful commercial path by finding the first industrial application for rare earths. Towards the end of the 19th Century, just when it was thought that electricity would replace gas for street lighting, he patented the «Auerlicht» which increased gaslight thanks to the effect of incandescence provided with a fragile sleeve suspended from metal wires made of cerium and thorium, surrounding the gas flame. Bombay, Paris, Berlin, Vienna… In 1913 300 million Auer lamps were manufactured. The Austrian Emperor Franz Josef honoured its creator by bestowing upon him the title «Baron von Welsbach». Today, his invention is still providing intense light in camping-gas lanterns. Another consequence of his invention capacity, which has also lasted up to the present time, is the flint for lighters, an alloy of cerium and iron. The invention replaced matches which had been used to light fires for the previous half century. Auer's practical approach shows how, although it is important to have energy readily available, and this all started off with the spark from a humble flint, it is equally important to know how to use it, making the most of it without increasing its consumption. These two points are basic for present-day society where handling energy is concerned.

The utilisation of rare earth elements has been transforming our society since the 1960s. The use of their elements is technically feasible because the energy, procedures and facilities are all available to isolate those metals. After Auer's work a century ago, the successive inventions of microprocessors (1971), magnets (1966-1983), the Internet (1981) mobile phones (1991) and smart phones (2005) increased the demand for rare earths; they have driven us into a high-tech society. Rare earth elements are in our pockets, e.g., in the form of bank notes and mobile phones, they are in our spectacles, if we wear them, in some zirconia jewellery, in our everyday lives, computers, screens, ovens

5 BAUMGARTNER, E., «Carl Auer von Welsbach a Pioneer in the industrial application of rare earths», in: «Episodes from the history of the rare earth elements» (C.H. Evans, Ed.), Kluwer Academic Publishers, London, pages 113-130.

and cameras, vehicles (cars, skateboards, etc.), refrigerators and freezers, tennis rackets and golf clubs, bicycles (whether electric or not), lights, etc.; they gives us quality of life in hospitals and dental clinics, optical fibre and Wi-Fi, transport, etc. The technology that we enjoy today is largely based on rare earths, to the extent that we would be going back to the 1960s if they did not exist. We could quite rightly say that thanks to their applications, after going through the Copper Age, the Bronze Age and the Iron Age, we have now reached the Rare Earth Age[6].

The aim of this article is to provide an overview showing why rare earth elements are vital to our society and how they interact with energy.

A great variety of uses

The history of rare earth elements is generally considered to consist of three stages: an initial stage beginning with their discovery (up to 1947) followed by their study (up to 1969), and ending with the development of applications (up to the present time) and their incorporation into everyday life. However, the facts that can be associated with each stage overlap. Auer's patents or the ongoing research into lasers and magnetism and their new physical-chemical properties are such examples. Rare earths received their biggest boost with the invention of the colour TV in the 1960s. That commercial success was closely linked to a sharp increase in mining with new methods in a bid to find these elements in a pure state, which paved the way for research into new properties and applications. Ever since, the scientific quest that emerged at the end of the 18th Century to obtain greater insight into the world around, rewarded by academic glory or scientific honours, has become the technological business of their applications, which greatly condition scientific research, focusing it on economic results. The giant that is modern-day high-tech society, is still imbued with the altruistic science of two centuries ago.

The role played by each one of the 17 rare earth elements in the world of applications is summarised in Table 2. However, several of them might be used in one single device.

6 ONDREICKA, B., SAMMAN, N., «Rare Earth», Sternberg Press, Berlín, 272 pages, 2020. https://www.tba21.org/#item--rare_earth--525. Consultation date 25/01/2021.

Scandium	Tracing agent in oil refineries; additive in halide lamps; aluminium hardener (bicycles, rackets, golf clubs, etc.); metal alloys for the aerospace industry.
Yttrium	Energy-efficient light bulbs; ceramics; metal alloys; laser cutting; improved fuel efficiency; microwave communication; LCD displays; temperature gauges.
Lanthanum	Electrodes for rechargeable batteries; catalysts for oil refineries; batteries for electric vehicles; high-tech digital camera lenses; video cameras; portable PC batteries; X-ray films; lasers.
Cerium	Catalysts for oil refineries; lighter flints; electrodes for rechargeable batteries; ceramic dyes; diesel oil additive for smoke breakdown catalysing; UV filters; metal alloys; lens polishers (glass, TV faceplates, mirrors, optical glass, silicon microprocessors and disc units).
Praseodymium	Lasers; electric motors (for example wind turbines, vehicles, drones); additive in the glass for welding goggles; to increase resistance to corrosion in magnets; pigment in glass and enamels; reflectors; airport signalling lenses; photo filters.
Neodymium	Electric motors (for example wind turbines, vehicles, drones); additive for glass (welding goggles, car headlamps, for example); ceramic condensers; electrodes for rechargeable batteries; magnetic resonance equipment for hospitals; high-power magnets for portables; lasers; catalysts for fluid fracking.
Promethium	Phosphorescent paints; nuclear batteries; source of beta radiation; radioactive source for thickness measuring instruments.
Samarium	Lasers; high-temperature magnets; nuclear reactor control rods.
Europium	Lasers; banknote authentication devices; liquid crystal displays (LCD); fluorescent lighting; additive for glass.
Gadolinium	Computer memories; lasers for steel cutting; X-ray tubes; contrast agents for magnetic resonance tests in hospitals; additive for glass.
Terbium	Lasers; fluorescent lamps; additives for neodymium magnets; lighting and displays; guidance & control systems.
Dysprosium	Hard disks (IT); additives for neodymium magnets; lasers.
Holmium	Lasers; the most powerful magnets manufactured; magnetic resonance equipment for hospitals.
Erbium	Lasers; solar panels; optical fibre signal maintenance; glass dyes.
Thulium	Lasers; X-ray radiography equipment (for example in dental practices); high power magnets.
Ytterbium	Optical fibre technology, solar panels, alloys (stainless steel), radiation source for portable X-ray equipment; lasers (for metal and hard plastic cutting); flares.
Lutetium	LED light bulbs; glass with high refractive index; X-ray screens; catalyst in oil refineries to produce petrol and diesel oil.

Table 2. Main applications of rare earth elements.

The chemical properties of rare earth elements are very similar, but their physical properties are not, which explains the specific nature of their optical and magnetic properties. In the consumer market, there is no single and uniform classification for rare earth applications and they are usually grouped into nine sectors: batteries, additives for glass, catalysts (oil refining, vehicles), ceramics, magnets, metallurgy (alloys, etc.), pigments and luminescent tubes (laser, lighting and illumination, LCD displays, etc.), polishing and others. The estimates made for 2020[7] can be seen in Figure 2. These estimates are no different from previous ones, for example, the estimate for 2015[8]. Half the production goes on magnets and catalysing. From an economic value perspective, magnets and luminescent tubes are the most profitable. The rare earths with the highest consumption ratings are[9] Neodymium (49%) and praseodymium (20%), as they form part

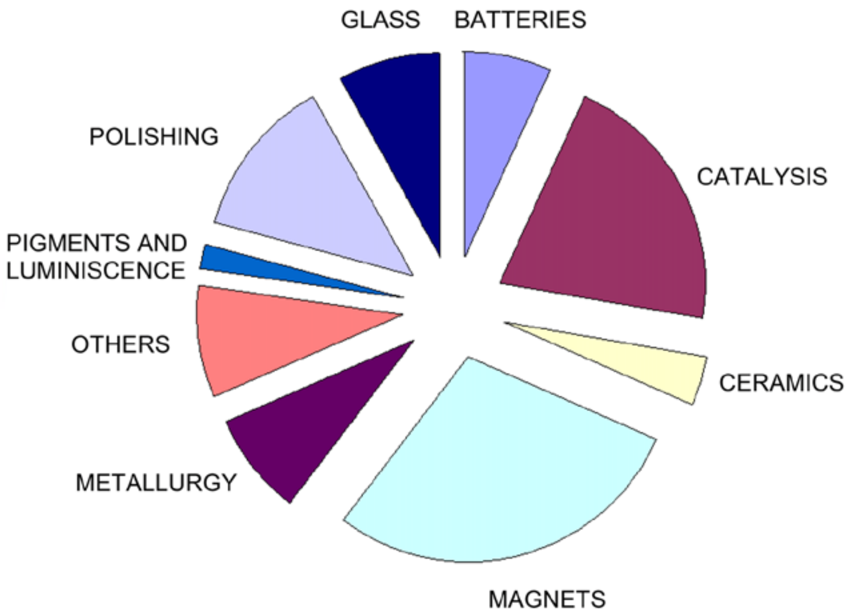


Figure 2. Rare earth element consumption distribution on the basis of their applications in 2020.

7 ROSKILL, «Rare Earths». https://roskill.com/market-report/rare-earths/ Consultation date 25/01/2021.

8 ZHOU, B., LI , Z., CHEN, C., «Global potential of rare earth resources and rare earth demand from clean technologies», Minerals, 7: 203, 2017.

9 https://www.statista.com/topics/1744/rare-earth-elements/ Consultation date 25/01/2021.

of magnets, followed by lanthanum (6%), cerium (4%) and terbium (4%); the rest are all below 2%.

However, the cost of the different oxides of these elements is linked to their rarity in the minerals and how difficult it is to separate them. Ytterbium and lutetium are exceptions because of their high price and limited production. Other outstanding oxides are[10] scandium oxides (US$ 955/kg 99.99% pure; November 2020 in EXM[11] China) and terbium (US$ 805/kg; idem). It must be remembered that prices vary on a monthly basis, depending on the market (Chinese, Hindu, etc.), how pure the oxide is, or even the volume purchased. Military uses are worth a separate mention, because of their importance in geopolitical games even if they include some of the aforementioned applications.

Military and optronic applications

The history of rare earths and uranium cross paths, as both appear together in some minerals and because, at times, nuclear experts were also involved in making use of the ores in rare earths. The Manhattan Project to manufacture the first two bombs, one a hydrogen bomb and the other a plutonium bomb, paved the way for an improved separation of rare earths. In this secret environment, three North American Scientists, Jacob Marinsky, Lawrence Glendenin and Charles Coryell, were contracted in view of their experience with rare earths and the similarities between rare earths on the one hand, and uranium and plutonium, on the other, so the three could research into the separation of radioactive isotopes. According to Marinsky,[12] the two most exciting projects developed at the Clinton Laboratories in 1944-45 were the discovery of Element 61 (promethium) and obtaining the radioactive source that Robert Oppenheimer needed to make an atomic bomb explode. Every aspect of this was shrouded in military secrecy, so the North American Army's announcement of its discovery was delayed until 1947. Promethium is the only rare earth element that could be correctly described as «rare». It is so

[10] https://en.institut-seltene-erden.de/unser-service-2/metall-preise/seltene-erden-preise/ Consultation date 25/01/2021.

[11] The importer has to pay the logistical cost of the goods from the supplier's storage facilities to the importers.

[12] MARINSKY, J. A., «The search for Element 61», in: «Episodes from the history of the rare earth elements» (C.H. Evans, Ed.), Kluwer Academic Publishers, London, pages 91-108, 1996.

rare in the Earth's crust that its total weight does not even reach one kilogram. It is radioactive and completely disintegrates in a few years. It is frequently excluded from the rare earths. What is needed for a few applications is obtained artificially in nuclear reactors, given that it is one of the elements yielded by uranium fission.

The Cold War led to the search for and development of surveillance systems for monitoring other countries and to the Space Race, which made it even more necessary for conducting research into applications and also increased the demand for rare earth elements. Power based on armies is supported entirely by the range of military technologies that those elements provide. Without them, countries would be unable to produce most of the equipment they need for defence purposes. Most nations are reluctant to provide information, whereas the USA is more transparent, albeit without furnishing details[13]. The uses to which rare earths are put, are grouped together under very general headings, such as targets and weapon systems, guiding and control systems and electric motors, or communication devices and screens for displaying analogue and digital data. Nonetheless, it is possible to obtain some information about the essential military applications[14]. They are used in the missile guidance and control systems that direct missiles and bombs to their targets (terbium, dysprosium, samarium, praseodymium and neodymium). The Patriot missile uses neodymium and samarium in its electric motors while its radiofrequency-based guidance systems require gadolinium, yttrium and samarium to magnetically control the flow of electronic signals in radar and sonar to sustain navigation. The SideWinder missile, which is guided by heat-seeking, has rare earth magnets in its fins to control the flight path. Smart bombs, precision-guided munition, of the Tomahawk cruise type, anti-ship (ASM) and ground-to-air (SAM) type missiles, as well as bunker busters need dysprosium, neodymium, praseodymium, samarium and terbium. Other examples are aircraft and warships. An F-22 fighter contains yttrium, terbium and erbium in its optical, detection and optical fibre systems (there are 400 kilograms of rare earth metals in an F-35). A nuclear submarine requires 4 tonnes, including europium and lutetium for its active and passive sonars. A Class Aegis-II destroyer carries 2.5 tonnes

13 EPA 600/R-12/572, «Rare Earth elements: a review of production, processing, recycling, and associated environmental issues», 2012.

14 https://www.defensemedianetwork.com/ Consultation date 25/01/2021.

and lasers for the detection of mines and countermeasures. The electric motors in the future´s guided military destroyer Zumwalt, of the North American Navy, need strong permanent magnets (terbium, dysprosium, samarium, praseodymium and neodymium). There are lasers mounted on such vehicles as tanks and armoured cars that enable the identification of targets up to 35 kilometres away and increase the likelihood of achieving direct impacts. Such examples include the Abrams tank (europium, neodymium, terbium and yttrium). Yttrium is utilised to improve the armour on military vehicles. Radar systems need at least europium and lutetium. Finally, an army depends on high-tech products to enable soldiers to communicate with their teams, whereas mobile phones, computers and touch screens are in everyday use. Current and future components for electronic war and radars strictly depend on rare earth elements. The strength of a modern army lies mainly on its technology, which is the reason why research and development are ongoing.

Civil and military researches are mixed in advanced countries and some successful applications are exchanged. This is the case with optronic systems. They are items of equipment consisting of radar, laser and electronic calculators applied to locating and automatically following targets, able to detect objects under any light conditions, evaluate their characteristics and carry out surveillance on them by means of images. The best military example is the Predator-type drone, which has civil purposes for the vigilance of critical and high-risk installations such as ports, airports, industries, thermal and nuclear power plants, etc.

Energy-related applications

The wide variety of technological possibilities that the properties of rare earth elements offer have been explained above. It is now worth examining in greater detail exactly how their potential can be applied to energy. Three categories can be distinguished, depending on how they are associated with energy: the first category directly concerns energy production; the second one involves improving energy consumption efficiency; and the third one concerns the means for making energy management easier. The three are combined in the emerging clean technologies, such as wind turbines, electric vehicles, rechargeable batteries and low-consumption lighting. The rare earth elements that are vital to clean technologies are lanthanum, cerium, neodymium, europium, terbium dysprosium and yttrium, most of the applications only requiring one or two of them. The quantities and the equipment in which they are used are shown in Table 3 where what stands out is the 120 kilograms of neodymium and 12 of dysprosium, on average, that are currently required for each megawatt of power in a wind generator. In the most extensively utilised model, both metals are located in the horizontal axis wind turbine, where a rotor composed of three blades attached to the bushing causes a shaft to rotate, that shaft being connected to a multiplier that raises the rotation speed to 1,500 r.p.m. to produce alternative energy that is transmitted to the grid. The generator operates in a similar way to a dynamo whose powerful magnet is made of a neodymium alloy (up to 30% Nd), iron and boron. The drawback is that it loses its magnetic properties at a temperature lower than other magnets, which is why dysprosium is included, and sometimes terbium, to improve performance. Rare earth elements are also utilised in the IT equipment at a wind farm, intended for control, management and communication purposes.

Another application that stands out in energy production utilises promethium, for the element is rare and the application very singular in nature. Promethium is used as a supply source for atomic batteries. The mass number 147 (number of protons plus neutrons) isotope of promethium is obtained artificially and on transmuting to samarium; it releases beta particles, that is to say, low-energy electrons, which prevents the need for heavy armour. It forms part of a small group of radioactive isotopes used in beta voltaic batteries. They are able to generate currents with very low voltage that are utilised in space craft. In the case of promethium-147, the battery lasts for about five years and can be applied with a military function to missile guidance systems to prevent interference with their computing systems.

One example of the second category, improving energy efficiency, is lighting. Rare earth elements enable less electricity to be used when applied to fluorescent tubes (linear fluorescent lamps: LFL), fluorescent bulbs (compact fluorescent lamps: CFL), and, recently, LEDs (light-emitting Diodes: LED). Since the start, when Auer's invention intensified gaslight, acting through thorium oxide (nowadays yttrium), which built up thermal energy from gas combustion and emitted it as infrared radiation, converted in turn into a brilliant visible light by the cerium oxide, a modern version of Auer's lighting by incandescence can be found in mercury fluorescent lamps. Mercury acts as an energy source and if the interior glass is coated with just under a gram of rare earth elements (Table 3), this is sufficient to produce light similar to daylight. That energy source can also be a cold LED light that, containing traces de europium and yttrium (Table 3), provides the diverse lighting that is so often found nowadays in houses, cars, signs, decoration, etc. LEDs are replacing fluorescent lighting because they save on energy and maintenance and control, while at the same time provide a variety of colours. It is predicted that over the next ten years[15] there will be a sharp drop in the demand for fluorescent lamps (LFL and CFL), whereas there will be twice the demand for LEDs. However, experiments are being conducted with LED lighting based on quantum dot (QD) nanotechnology[16], which could stir up the future market and distance it from rare earths.

Application	by	Dysprosium (kg)	Neodymium (kg)	Cerium (g)	Europium (g)	Lanthanum (g)	Yttrium (g)	Terbium (g)
Wind turbines	MW	12	120					
Electric vehicles	motor	0.075	0.45					
Electric bicycles or scooters	motor	0.031	0.038					
NiMH batteries	battery		0.255	860		610		
Fluorescent tubes	lamp			0.18	0.041	0.077	0.56	0.045
Fluorescent lamp	lamp			0.14	0.095	0.462	1.3	0.105
Light-Emitting Diodes (LEDs)	lamp				0.0004		0.005	
Catalytic converters	car			20				

Table 3. Consumption of the rare earth elements in each one of their main clean energy applications.
Based on: Zhou, B., Li, Z., Chen, C. 2017. Global potential of rare earth resources and rare earth demand from clean technologies. Minerals, 7: 203.

Electric motors need neodymium and dysprosium in their magnets. The stator's rotating magnetic field drag the rotor´s fixed magnetic field, making it rotate and causing a set of gears to move the car wheels. Less than half a kilogram of rare earths is required, although

15 ZHOU & CHEN, Note 8.

16 https://electricaltrends.com/2019/06/03/impacts-on-lighting-if-china-weaponizes-rare-earth-metals/ Consultation date 25/01/2021.

a hybrid car may contain up to eleven kilograms in other items of equipment. Their high performance and small size make them suitable for hybrid and electric cars, scooters, bicycles and even drones. The automobile industry is seeking technological alternatives to permanent magnet electric motors containing rare earth elements. At the present time, there are two possibilities[17]: one, electric motors with an external excitation system that replaces the magnets, and the other, magnets composed of magnetic materials that perform the same function and minimise the need for rare earths. In spite of everything, no other magnet can achieve the same high performance. According to Da Vukovich, Chairman of Alliance LLC, it is not really possible to replace rare earth magnets[18].

Neodymium is a metal that is playing a major role in current plans to exploit wind energy on a large scale, especially marine wind energy. The constant increase in the manufacture of wind turbines and hybrid and electric vehicles has brought about an equally steady rise in the demand for neodymium. Toyota predicts that demand for neodymium will exceed supply as from 2025 and is now developing engines using half the amount of rare earth metals. The Green Agenda, an objective for many national governments and international bodies to reduce carbon emissions, will lead to a growth in the demand for the rare earths needed to generate renewable energies and to provide zero-emission transport. It has been estimated that by 2030[19] there will be a 35% increase in MW provided by wind energy, the use of Ni-MH will double and there will be 14 times as many electric vehicles. The Roskill Perspectives Report on the rare earths market[20] for that year, which contains a detailed breakdown of the demand, assessing technological trends and industry trends and their impact on the consumption of each element by end-use markets, predicts that rare earth magnet applications will account for 40% of the total demand for those metals.

Energy storage falls into this second category: electrochemical batteries for portable devices and hydrogen storage[21]. Recharge-

[17] https://www.hibridosyelectricos.com/articulo/tecnologia/motores-electricos-tierras-raras-son-posibles-son-alternativas/20200124185136032768.html Consultation date 25/01/2021.

[18] Ibidem.

[19] ZHOU & CHEN, Note 8.

[20] ROSKILL, Note 7.

[21] JIANG, Z., WANG, J., CAO, D., «Research Progress of Rare Earth-Based Hydrogen Storage Alloys», Key Engineering Materials, 861: 354-362, 2020.

able nickel metal hydride batteries (Ni-MH) are frequently used as sources of energy. They form part of consumer electronics: PCs, telephones, audio equipment, televisions, calculators, GPS systems, digital cameras, video players and recorders, etc. They are most extensively used in electric and hybrid vehicles. The battery cathode is made with an alloy (mischmetal) of rare earth elements that contain varying proportions of cerium (45-50%), lanthanum (25%), neodymium (15-20%) and praseodymium (5%). Ni-MH batteries are replacing nickel-cadmium batteries for several reasons. They provide twice as much energy, they are not pollutants and the metals can be recovered to manufacture new batteries. They are also under threat from those that use lithium, which offer a similar capacity at half the size, albeit at a higher cost. The demand for Ni-HM batteries is not expected to decrease, in fact, it is predicted that their number will double by 2030[22].

The third category contains all the applications supporting the systems that control energy sources and distribution, namely communication systems, IT equipment, security controls, etc. The need to have reserves of energy means that experiments are being conducted for hydrogen storage with different alloys[23]. The alloys of lanthanum-nickel (LaNi5) or Mm-nickel-aluminium-cobalt-manganese are very attractive (Mm is the symbol for mischmetal). Rare earth hydride deposits form crystalline networks in which hydrogen gas molecules can be adsorbed. The gas is later released on being slightly heated under suitable catalytic conditions, enabling it to be used as a fuel.

Several rare earth isotopes are involved in controlling energy of nuclear origin, samarium, gadolinium, dysprosium, holmium and erbium. Samarium-149 is unusual in that it is «relatively» stable, because it disintegrates so slowly that fission has not yet been observed, that is to say… It requires more time than the age of the Universe! It is also a nuclear poison, i.e., it is a material that absorbs neutrons, useful for reducing the high initial radioactivity of the nuclear fuel, the uranium in the reactor core, causing the disintegrations to slow down. It is the second most efficient in this process after the xenon-135 isotope. The disadvantage of samarium is that as it does not disintegrate it can only be operational

22 ZHOU & CHEN, Note 8.

23 UCHIDA, H., HARADA, M.R., «Application of hydrogen storage alloys», in: «Science and Engineering of Hydrogen-Based Energy Technologies» (P.E. de Miranda, Ed.), Academic Press, London, pages. 290-302, 2018.

for about 20 days[24]. Something similar happens with gadolinium-157[25]. It is a burnable poison (it disintegrates) that is loaded into the reactor core as an additive to control the reactivity of the surplus and prevent power peaks in some areas of the reactor without having to apply the control rods. Gadolinium trioxide is generally used in boiling water reactors. Soluble poisons are also applied in emergency shutdown systems by injecting gadolinium nitrate solutions directly into the reactor coolant. Likewise, natural dysprosium easily absorbs neutrons and is alloyed with steel; its oxide combined with nickel being added to a special cement used to cool the nuclear reactor bars. Holmium is also applied on occasions as a consumable poison to keep a nuclear chain reaction under control. In Russia, research into developing a uranium-erbium fuel for its RBMK-type reactors began after the Chernobyl accident, in order to improve performance and safety. Erbium isotopes 166 and 167 have been validated as nuclear fuel absorbers at the Leningrad, Kursk and Smolensk Nuclear Power Plants[26], while uranium-erbium fuel was adopted[27] first for RBMK-1500 reactors and later for RBMK-1000 reactors.

Finally, lanthanum and cerium must be included because of their contribution to clean technologies, as catalytic converters for automobiles[28]. In the 1990s, catalysts were developed with platinum, palladium, rhodium and cerium oxide deposited on aluminium and lanthanum oxide. Their function is to reduce the pollution caused by the post-combustion gases emitted through vehicle exhaust pipes. The unburnt hydrocarbons, the carbon monoxide and the nitrous oxides produced by explosion diesel engines are processed to carbon dioxide, nitrogen gas and steam before being released into the atmosphere. New catalytic converters were introduced later containing cerium in the particulate filters; which facilitates soot combustion in the filter, reducing their expulsion to 1%. Cerium oxide can even be supplied as a liquid catalyst in the fuel. This additive, which is well-known for its effectiveness, accompanies the exhaust gases and reduces

[24] O'BRIEN, J., «Fundamentals handbook nuclear physics and reactor theory». U.S. Department of Energy, 2015.

[25] Ibidem.

[26] BYSTRIKOV, A.A. *et al*., «Experience in using uranium-erbium fuel in power-generating units with RBMK-1000 reactors», Atomic Energy, 100: 165-170, 2006.

[27] FEDOSOV, A.M, «RBMK Uranium-Erbium Fuel», Atomic Energy, 124: 221-226, 2018.

[28] PREGO, Note 2, pages 88-89.

the combustion temperature of the soot, which helps to clean the turbo and the particle filters.

The bibliography speaks: reporting on the research work

Rare earths first came to be known to humanity in Sweden in 1787 and the discovery of the last one was reported in the USA in 1947. In between those years scientists informed their colleagues through personal meetings about any breakthroughs, and published their findings mainly in national German, English and French scientific journals. Any breakthroughs that were published in other languages went unnoticed. For example, in 1897, when Konstantin von Chrustchoff announced in a Russian journal that he had separated two new elements, which he decided to call glaucodymium and russium, this remained CPSL outside his country. Exchanging ideas and experiences helped research to progress, and this was a hard work for European scientists (in Sweden, France, Austria, Switzerland and Germany; see Table 1). Urbain summarised the problems involved in separating and identifying rare earth elements in 19th Century in one brief sentence: «it was a sea of errors, and the truth was drowned in it»[29]. Publishing became much better in the next century and the applications, both the purely scientific ones (geology, astronomy, etc.) and the applied ones (materials science, engineering, etc.), appeared in publications that circulated internationally. Monitoring the works disseminated with an extensive bibliographical database is very revealing.

The technological platform «Scopus» was developed by Elsevier but has been managed independently by an international editorial board since 2009; the Spanish National Research Council (CSIC) library network has access to it. The contents, the titles of 24,500 seriated publications from more than 5,000 publishers in 140 countries, were examined via the Scopus website[30] and are the source of information followed. To begin with, a selection has been made of the publications that serve scientific journals, chapters of books and thematic reviews where «rare earths» appears in the titles or key words; the search was carried out on an international level and also in Spain. 86,916 documents were

[29] TRÍFONOV, D. N., TRÍFONOV, V. D., «Como fueron descubiertos los elementos químicos». Editorial MIR, Moscow, P. 141, 1984.

[30] https://www.scopus.com/search/form.uri?display=basic Consultation date 25/01/2021.

found of which 943 corresponded to Spain (1.1%), of which 59 were written in Spanish, mainly by South American authors. In both cases scientific articles are predominant, 96.8% and 96.9%, respectively. Figure 3 shows the number of documents published and the year of appearance up to 2020. The first document, an article, appears in the year 1881, but very few publications appeared until after the Second World War, by which time they were exceeding ten per year (Figure 3). By then, new methods for separating rare earths had been found and purification methods were gradually improving, which enabled the researchers to study new properties, such as the laser effect and applications to magnetism and optics. In 1962, publications exceeded one hundred, which marked the beginning of the golden age (Figure 3). Rare earth elements came to fully form part of everyday life (not forgetting Auer's contributions) with the commercialisation of colour televisions using europium.

In Spain (Figure 3) the database began to keep records in 1979, and by 1992, over ten documents per year were being included. This was followed by an upward trend, albeit with certain irreg-

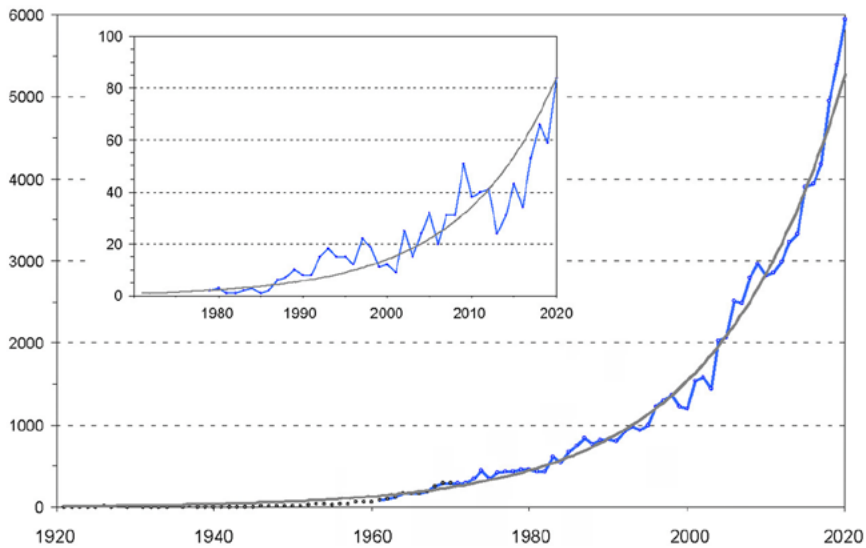


Figure 3. The number of scientific publications appearing annually in the world, dealing with rare earths, according to the Scopus bibliographical base, which has collected 86,916 since 1882. The data have grown exponentially since 1961 with an R2 adjustment of 0.983. The same can be seen in the top left corner for Spanish output. There have been 943 publications, starting in 1979; this shows a similar trend with an R2 adjustment of 0.831.

ularities, such as the fall in the period from 2013 to 2016. In general, these vicissitudes are similar to the international trends, where there was a period of expansion marked by an exponential increase in scientific publications. In that respect David Abraham[31], strategist in the field of natural resources for the North American publication Technology, Rare and Electronic Materials Centre[32] considers that research is crucial for discovering the secrets of materials science and «Governments should also work more closely with research institutions and the tech industry to better understand future demands for rare metals». If one bears this in mind, and reviews the most detailed scientific documents and analyses them by countries, financing sources and the affiliation of the authors, the news is not good for western culture. The research work has mainly been carried out by Chinese authors. The largest number of writers regarding rare earths belong to the Chinese Academy of Sciences, followed a long way behind by the Russian Academy of Sciences, with half that number. Eight of the ten most frequent affiliations regarding rare earths are either Chinese (6) or Russian (2). Only two appear from elsewhere: The French CNRS (in third place) and the Japanese University of Tohoku (in tenth place). China also predominates pursuant to the main sources of financing for articles, followed by the USA (only one third of the Chinese quantity) and Russia (one ninth); other countries appear to a lesser extent, Japan and Germany, with industrial interests, and Brazil, because of its mining activities. If one takes into account where the research was actually carried out, the findings are the same. In the top ten, China is far ahead of the rest as the leading country (34%), with the USA in second place a long way behind (14%), followed by Japan (8%), Germany (7%), Russia, France and India (each with 6%), England (4%) and finally Poland and Canada (3% each). Spain's contribution is poor, as can be seen from Figure 3. The research, according to the documents published, is mainly done by scientists affiliated to the various Institutes of the Spanish National Research Council (CSIC), followed by universities, headed by the Universidad Autonoma and the Universidad Complutense both in Madrid. All of these receive financing from the State through the Ministry that is relevant to research matters and, to a lesser extent, from the European Union.

31 ABRAHAM, D.S., «The elements of power». Yale University Press, p. 226, 2015.

32 http://www.tremcenter.org/trem/about-us/mission/ Consultation date 25/01/2021.

China clearly plays a predominant role, and the reasons for this will be discussed below. This leading role also explains why The Chinese Society of Rare Earths runs the only scientific journal in English that publishes work on aspects of the basic theory and the applied science in the field of rare earths: the «Journal of Rare Earths»[33], dependent upon Elsevier. It is the first of the Top-5 journals that are responsible for most of the scientific articles published about rare earths, followed closely by the European interdisciplinary journal «Journal of Alloys and Compounds», which is not specifically focused on rare earths. The next two follow the same line because they concentrate mainly on applications, including rare earth applications. They are the «Journal of Magnetism and Magnetic Materials» and the «Journal of Luminescence», and finally, the fifth one is another Chinese journal, the «Journal of the Chinese Rare Earth Society». The most specialised aspects of rare earths are brought together in the series of books included in the «Handbook on the Physics and Chemistry of Rare Earths»[34] (Elsevier). This Handbook was initiated in 1978 by Karl A. Gschneidner Jr. (1930-2016)[35], nicknamed Mr. Rare Earth. He worked for more than 50 years in the Ames Laboratory and supervised 41 volumes (until he retired in 2011), marking a period when this field was dominated by North America. Volume 58 appeared in 2020, so there are now 314 monothematic chapters that cover the many and varied aspects of the rare earth sciences, including chemistry, life sciences, materials sciences, and physics. All this literary scientific activity, together with the exponential growth curve of publications (Figure 3), are clear examples of the large amount of attention paid to rare earth elements; this attention will not wane in the next few years. Both pure and applied scientific research into these elements has moved from Europe to North America, as a result of the negative consequences of the European «Civil» Wars in the 20th Century, and, although the post-war situation in China was no better than the situation in Europe, it is now China that is leading the field.

Now that global interest in rare earth elements from a scientific perspective has been demonstrated, it is important to find out

33 https://www.sciencedirect.com/journal/journal-of-rare-earths/about/editorial-board Consultation date 25/01/2021.

34 https://www.elsevier.com/books/book-series/handbook-on-the-physics-and-chemistry-of-rare-earths Consultation date 25/01/2021.

35 PECHARSKY, V., «Karl A. Gschneidner Jr (1930–2016)», Nature Mater 15, 1059, 2016.

what the articles focus on. The subject matter has been grouped into seven different kinds (Figure 4). The percentages are similar for Spain as they are for the world in general, the figures for Spain showing a slight increase (2%) for Materials Science and Chemistry, and a slight decrease (3%) for Earth and Planetary Sciences. It is the section covering the Materials Science that

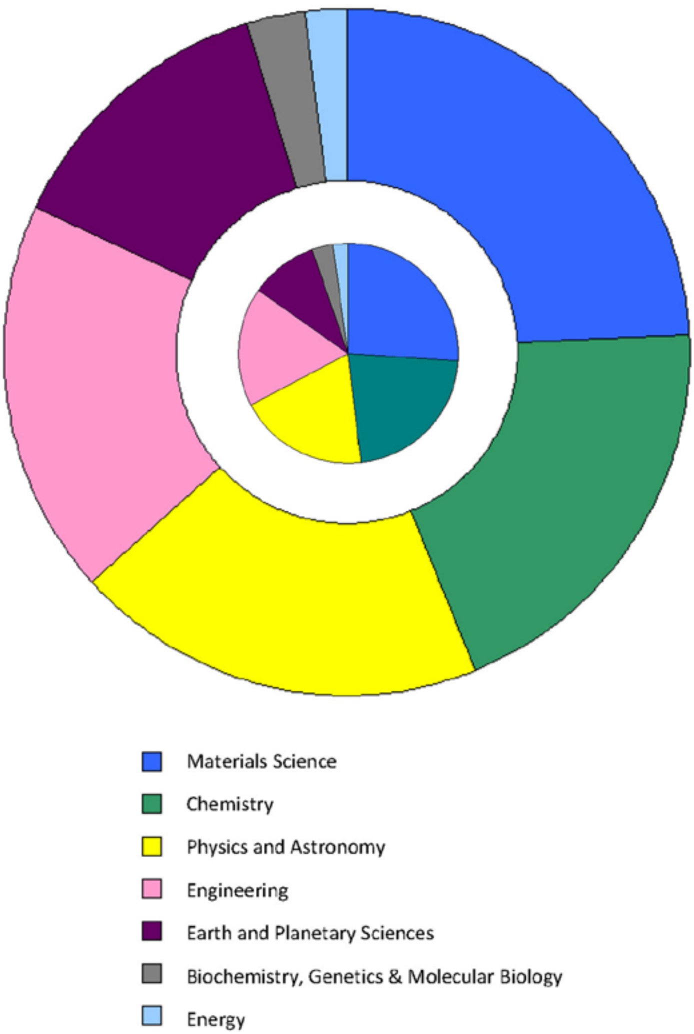


Figure 4. Share of research work contributions involving rare earths in the scientific journals. The inner circle refers only to Spain and the outer ring refers globally to the world. Engineering includes Chemical Engineering while Earth Sciences includes the Environment.

has received the greatest scientific attention in the world in this percentual classification, followed by chemistry. Energy is seventh in interest with 2.0% (2.2% in Spain) and its global influence is growing exponentially with an adjustment of 0.92 for R^2. Although publications did not exceed twenty a year until 1987, there has been a sharp increase since 2009, the year in which over a hundred articles were published for the first time, the figure of 326 being reached in 2020. China also stands out when Energy is the subject matter, being responsible for 902 publications from a total of 3,174 documents. Spain comes twelfth in the world rankings.

Sources of rare earth metals: the past conditions the present

The current availability of sixteen rare earth elements, i.e. 14 lanthanides (promethium is not considered), scandium and yttrium, in the Earth's upper crust (Figure 1) is determined by its stellar origins, the formation of our planet and the chemical properties in the process whereby the minerals were crystallised in the lithosphere. Only scandium could have had nuclear fusion origins inside the stars (stellar nucleosynthesis[36]), as is the case with the chemical elements up to iron. The rest emerged during the explosion as supernovae of massive stars. This event provided sufficient energy to overcome the electric repulsion between protons and to bring the strong nuclear force into action that keeps them united in an atomic nucleus. The chemical elements up to uranium were formed by addition of neutrons[37], among them, yttrium and the lanthanides. This different process makes them less abundant in our solar system, around seven orders of magnitude, i.e., ten million times more exiguous than iron (Figure 1). That is also why scandium is about one hundred times more frequent than the lanthanides (Figure 1). Furthermore, the abundance of the elements decreases as their number of protons grows (Z), in such a way that the expected order of abundance would be on the decrease from scandium (Z= 21) to lutetium (71). Thus cerium (58) and neodymium (60) are among the least profuse lanthanides and the least profuse of all is lutetium (71). Lanthanum (57) should be more abundant than cerium (58) but this is not so. This ought to be the case with the other lantha-

36 LANGMUIR, C.H., BROECKER, W., «How to build a habitable planet». Princeton University Press, Princeton, pages 51-82, 2012.
37 Ibidem.

nides, yet they appear in sawteeth, because the ones with even atomic numbers are more numerous than their neighbours with odd numbers (Figure 1). A nuclear effect provides greater stability for atomic nuclei with even numbers of protons or neutrons (Oddo-Harkins Rule)[38]. In that sense, it is understood that the odd-numbered scandium (21) and yttrium (39) are less frequent in the Universe than their even-numbered neighbours (Figure 1): five orders of magnitude less than calcium (20) or one order of magnitude less than strontium (38). This difference makes some rare earths rarer in nature, especially the lanthanides such as thulium or lutetium, affecting the mineral extraction processes and their commercial cost.

One single cloud of matter configured the Sun, the Earth and all the other planets, which acquired different compositions while the solar system was being formed and as it evolved. When the Earth was being formed, the elements were distributed, in accordance with the cosmochemical classification devised by Goldschmidt[39], into lithophiles, siderophiles chalcophiles and atmosphiles. The rare earth elements are all lithophiles, i.e., silicate loving. The chemical similarity between them comes from their electronic structure. That is why they are always present together in their minerals, in greater or smaller proportions. In nature, their atoms do not appear in the form of metals without electric charges but as positive ions that have lost three electrons. The progressive increase in protons causes the force of attraction to increase from lanthanum (57 protons) to lutetium (71 protons) and the size of the trivalent cation (considered to be a sphere), decreases to 1.02 ten billionth of a metre (Å) to 0.86 Å. This fact marks a small yet basic difference that determines which one of them will be incorporated first into the crystals that form when a liquid cools, whether it is water or magma. In magmas, the elements[40] from lanthanum to samarium strongly tend to remain at the molten phase where they accumulate. However, in hydrothermal solutions this happens from gadolinium to lutetium, as well as yttrium, because their ionic radius (0.90 Å) is similar to that of holmium. When one of the processes is predominant there is usually an exploitable deposit. Most of the Earth's crust was formed

[38] ODDO, G., «Die Molekularstruktur der Radioaktiven Atome», Zeitschrift für Anorganische und Allgemeine Chemie, 87: 253-268, 1914.

[39] GOLDSCHMIDT, V.M., «Geochemistry», Oxford University Press, London, 742 pages, 1954.

[40] This is another grouping that usually appears for the light and heavy rare earths.

from the mantle (lying at an average of 33 kilometres below the continents) about 2,500-2,000 million years ago. At that time, light rare earths amassed in the molten rocks, which took them along in the differentiation of the Earth's crust, impoverishing the mantle in them[41]. If the ascending magmas transport carbon dioxide, the carbonates are strongly associated with light rare earths giving rise to deposits that are worth exploiting. These are their main deposits. Furthermore, the secondary deposits are of hydrothermal origin, forming mineralisation in the seams. Weathering of the Earth's upper crust is another powerful mechanism for concentrating rare earths. That is how laterite clays were formed, after the intense chemical weathering of granite, creating major deposits of heavy rare earths that cost little to extract in the subtropical zones of China, Madagascar and Laos. As a result of all the above-mentioned processes[42], more than 270 minerals have been discovered that contain a rare earth element as an essential component of their chemical formula, another new one often being added every year. Yet only eleven minerals are exploitable, to a greater or lesser extent[43]: fluorocarbons (bastnäsite, parisite, synchysite), phosphates (monazite, xenotime, churchite), silicates (allanite, eudialyte, laterite) and oxides (loparite, fergusonite). In the case of light rare earths, the most common deposits are monazite, bastnäsite and loparite (95% of the total extracted[44]) whereas xenotime and laterite clays are the most frequent deposits for heavy rare earths.

It has been considered that if demand remains at 2017[45] levels, the reserves of rare earths on our planet will be sufficient for another 900 years. At present, there is an upward trend of about 10% per year, so those reserves could run out by midway through the 21st Century. The predictions made by other authors are more optimistic[46]. They do not think there is going to be a shortage this century, although there would be an increase in their prices due to extraction costs. Recent discoveries of deposits suggest that that prediction is not correct.

41 CHAKHMOURADIAN, A.R., WALL, F., «Rare Earth Elements: minerals, mines, magnets (and more)», Elements, 8: 333-340, 2012.
42 Ibidem.
43 Ibidem.
44 GSCHNEIDNER, K.A.Jr., PECHARSKY, V.K., «Rare-earth element», Enciclopedia Britannica, 2019.
45 Ibidem.
46 HENCKENS, M.L.C.M. *et al*., «Mineral resources: Geological scarcity, market price trends, and future generations». Resources Policy, 49: 102–111, 2016.

Space mining has commenced thanks to the cosmochemical knowledge obtained about chemical elements and their minerals, and this is the case with rare earth elements. Asteroid mining is covered by international treaties concerning Space Laws[47]: the Outer Space Treaty (1967) signed by 110 countries in 2020. Moreover, specific legislation has also been passed in some countries: in 2015, the Commercial Space Launch Competitiveness Act was passed in the US (abbreviated to The Space Act, and signed by President Barack Obama). It granted its citizens ownership rights over space resources. A year later, it was followed by the EU initiative for asteroid mining. US and Japanese space probes (Hayabusa Missions) have travelled or are still travelling (OSIRIS-Rex from the NASA) to collect samples of asteroids, now regarded as a source of strategic resources. The mining space race includes private initiative. The company Planetary Resources (2012) intends to develop a robot industry for asteroid mining. The British firm Asteroid Mining Corporation (2016) prepares satellites to explore asteroids. They attract millions of dollars in private investments despite being far from their goal, to put themselves in the front line where a potential space business is concerned.

Many groups, both public and private, see the Moon as the Earth's «eighth continent»[48]. During its formation, the lower gravity left a sea of magma trapped between the mantle and the crust; as it slowly solidified some elements migrated towards the crust forming deposits with large potassium (K) content, rare earth elements (REE) and phosphorus (P). They (called KREEP) are abundant in the largest of the lunar seas, *Oceanus Procellarum*. It is a dark and flat tract covering 1,692,000 square kilometres on the near (visible) side of the Moon, where several spacecraft and probes landed as part of the US Surveyor and Apollo Missions, the Soviet *Luna* Mission and the Chinese Rover-Robot *Cháng'é Yutu* Mission in 2013. On the occasion of this success, Ouyang Ziyuan, member of the Chinese Academy of Sciences, stated[49]: «There are a lot of resources [in the Moon], especially rare minerals, titanium, uranium that are very rare on Earth, and these resources could be

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[47] ROSENDAHL, M., «Galactic Preservation and Beyond: A Framework for Protecting Cultural, Natural, and Scientific Heritage in Space», William & Mary Environmental Law and Policy Review, 43 (3): Article 5, 2019.

[48] KLINGER, Note 48, p. 230.

[49] RINCON, P., «What is China looking for on the dark side of the Moon?», 2018. https://loozz.com/chile/what-is-china-looking-for-on-the-dark-side-of-the-moon-2/ Consultation date 18/02/2021.

used without restrictions». Chinese exploration of the Moon has been taking place through the *Chang'e* Missions. The first two to collect information in orbit, the next two to carry out operations on the surface of the satellite, and the last two to bring back samples. The fifth mission came back to Earth on 16 December 2020 with about two kilograms of soil samples and some lunar rocks. The European Space Agency has signed a mutual technological collaboration agreement with the China National Space Administration. In contrast, the 112th US Congress prohibited NASA from participating in bilateral agreements and coordination agreements with China[50]. In her extensive and exhaustive review of this matter in the chapter of her book entitled «Extraglobal Extraction», the geographer Julie Klinger, Assistant Professor of International Relations at Boston University, adds a bit of common sense to the situation by concluding[51] that «surely we can do better: both in finding the reasons to explore the cosmos, and in our everyday production and consumption of rare earth elements», because «the race to mine rare earths on the Moon has less to do with actual resources scarcity and much more to do with how rare earth elements mining in these places [the Brazilian Amazon, Afghanistan or Greenland] might serve frustrated bids for territory, power, and control».

Periods in the exploitation of rare earths

Coming back down to Earth, before 1890 there was no commercial market for rare earth elements. The Swedish mine at Bästnas supplied it to scientific laboratories. Auer's inventions that lit up the world began the industry and extended rare earth mining activities to Brazil and India. Later, during the Manhattan Project, major breakthroughs were made in studying the chemistry of rare earth elements, especially lanthanides because of their similarity to actinides (uranium, neptunium, plutonium, etc.). However, until the end of the 1950s commercial demand for rare earth elements was limited, not exceeding two thousand tonnes a year,

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50 Sec. 1340. (a) *None of the funds made available by this division may be used for the National Aeronautics and Space Administration or the Office of Science and Technology Policy to develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company unless such activities are specifically authorized by a law enacted after the date of enactment of this division.* Department of Defence and Full-year Continuing Appropriations Act, 2011. United States Congress. https://www.congress.gov/112/plaws/publ10/PLAW-112publ10.htm

51 KLINGER, Note 48, pages 227.

and that demand was catered for from mines in the two aforementioned countries. Knowledge of the properties, especially the optic and magnetic properties, of the rare earth elements paved the way for industrial applications, which in the following decade triggered the search for and exploitation of new deposits in South Africa, the USSR and the US. Subsequently, a fresh impulse was given in the 80s when they were applied to rare earth magnets, and consumption has now reached 60,000 tonnes per year.

US domination: Mountain Pass Mine

The US Mountain Pass Mine (California) is often used to exemplify an important period (1965-1984) in the industrial use of rare earths. For twenty years that mine was the biggest source of REEs in the world. The resources were discovered in 1949 during prospection activities that detected a radioactive vein. Uranium extraction commenced in 1952. The deposits were rich in barium carbonate containing 8-15% bastnäsite, associated with minerals that included thorium. Thorium is a lithophile element that is present in nature as a tetravalent cation with an ionic radius similar to the radii of the lanthanides, so it is usually an unwanted companion in rare earth minerals. The firm Molycorp Inc. operated it as an open cast mine to cater for the demand for europium that arose with the commercialisation of colour television. The history of Mountain Pass is a good example of the changes that rare earth mining underwent and the collapse of US mining. Between 1984 and 1998 a series of spillages occurred affecting the wastewater channels that contained radioactive waste. Apparently, President Richard Nixon approached the mining executives with a proposal for subcontracting some of the processes to China in order to reduce environmental liability in California and cut down on cost[52]. The refining plant was closed down and only a concentrate of bastnäsite was produced, which was then exported for treatment. The strict environmental regulations and the market prices, which rendered mining unprofitable, led to its closure in 2002. In 2007 an attempt was made to refloat it with the backing of Wall Street and the Pentagon; exports of concentrates returned. In 2011, Molycorp purchased the Estonian company Silmet[53] in order to process rare metals, and signed an

52 KLINGER, Note 48, p. 112.

53 Until 1989, Silmet supplied nuclear materials to the USSR; as from 1970, it processed loparite from the Kola Peninsula, extracting the rare earths. At present time

agreement with the Japanese companies Sumitomo and Mitsubishi to supply rare earths and also with the catalytic converter manufacturer W. R. Grace & Co. The drop in prices scuttled the project in 2014, once many of the most profitable shares had been sold on to Neo Materials, linked to China[54]. US dependence on rare earths had fallen under Chinese Control! Mountain Pass sent its rare earth concentrates to China for processing. In this context, the Chairman of Green & Co., a firm whose success was recognised in 2020 in Hill's Top Lobbyist List, which helps companies to wade through the complexities of the US Government, stated that «the Department of Defence had taken note, having recently solicited industry for options on rare earth separation capability, which could result in direct investment. These fixes, properly executed, represent the best chance to the U.S. has at revitalizing a crippled industry essential to our national security»[55]. In 2019 USA produced 26,000 tonnes of rare earths (second highest producer in the world; Table 5) coming exclusively from Mountain Pass, purchased by MP Mine Operation (10% Chinese capital), which had resumed mining activity and refining the year before. A new mine rich in heavy rare earths is now being opened in Round Top Mountain (Texas), as well as a pilot plant at Wheat Ridge (Colorado) for the complete processing of rare earth elements; once it has proved successful, it will be relocated in Texas for commercial processing. In the USA, the project is considered to be strategically important for national security in key sectors, including defence and energy, in order to manufacture cutting-edge technology[56]. In that respect, on 30th September 2020, the Trump Administration signed an executive order that declared a national emergency in the mining industry, a measure designed to boost the production of rare earth minerals[57].

NPM Silmet AS refines rare earth elements to produce neodymium iron-boron alloys, neodymium ingots and *mischmetal*.

54 GREEN, J.A., «The collapse of American rare earth mining – and lessons learned», Reagan Defense Forum, 2019. https://www.defensenews.com/opinion/commentary/2019/11/12/the-collapse-of-american-rare-earth-mining-and-lessons-learned/ Consultation date 18/02/2021.

55 Ibidem.

56 NS Energy, 2020. https://www.nsenergybusiness.com/projects/round-top-rare-earth-critical-minerals/ Consultation date 25/01/2021.

57 International Banker, «Rare-earth elements: will China constitute its market dominant?», 2020. https://internationalbanker.com/brokerage/rare-earth-elements-will-china-continue-its-market-dominance/#:~:text=%E2%80%9CThe%20Middle%20East%20has%20its,China%2C%20remarked%20back%20in%201992. Consultation date 25/01/2021.

The People's Republic of China joins the world of rare earth elements

After some years of interregnum (1984-1991), when diverse mining sources of rare earth coexisted, the period of Chinese domination began. The Chinese leader Deng Xiaoping (1904-1997) caused a stir when he broke away from the agricultural model imposed by President Mao (1893-1976) and stated that «The complete statement should be that science and technology constitute a primary productive force. The future of agriculture will eventually lie in bioengineering and other highly advanced technologies».

1976	The Chinese leader Deng Xiaoping (1904-1997) breaks away from the agricultural model imposed by President Mao (1893-1976) and states that «The complete statement should be that science and technology constitute a primary productive force. The future of agriculture will eventually lie in bioengineering and other highly advanced technologies». There is a great desire for the country to be technologically independent from foreign countries.
1978-89	The annual production of rare earths increases by 40%. Innovative Science & Technology programmes are initiated.
1986	Deng Xiaoping states that «the Middle East has oil, China has rare earths» Approval is given to the 863 Programme (a combination of military and civil projects) focused on biotechnology, space technology, information technology, laser technology, automation, energy technology and new materials.
1990s	Exports of oxides and metals already extracted from rare earth minerals begin, causing a plunge in world prices. President Jiang Zemin (Electrical Engineer) announced that it was necessary «improve the development and application of rare earth, and change the resource advantage into economic superiority». At the end of the decade products of greater value were manufactured: magnets, luminescent products and compounds for glass polishing.
2000s	President Hu Jintao (Hydraulic Engineer) stated that «Science & Technology are the backbone of the Chinese development strategy». China grows at the expense of Western industrial dynamism and uses its richness to capture companies. Systematic restrictions (high taxation) imposed on rare earth exports.

2010s	The 12th Five-Year Plan (2011-15) backs the scientific and creativity boom. China absorption of Western jobs. Manufactures finished products, such as electric motors, computers, batteries, screens/displays, telephones and portable music devices. Rare earth metals require an export licence and the export quantities permitted are halved, though no quotas are imposed on the amounts that can be sold abroad.
2013	President Xi Jinping (Chemical Engineer) assumes a scientific concept for developing Chinese Socialism and a security policy for the supply of minerals (from Africa, for example).
2016-20	Five-Year Plan based on innovation and technological progress. It permits the absorption of patents from joint ventures established in China. «Rare Earth Industry Development Plan» (2016) with the initiation of environmental protection, the consolidation of that industry and the development of new materials.
2025	In 2013 Gan Yong, President of the «China Rare Earth Industry Association», put China's long-term policy into words: «The real value of rare earths is obtained in the end product». A plan is set by China to become the world leader, including establishing 40 industrial innovation centres in order to provide expertise through discovery of new properties inherent to rare earth elements, registering patents and starting to operate future applications. To be a winner in the energy and digital transition, and the same in the military field.

Table 4. Steps taken by China involving rare earths.

This burning desire to achieve technological independence from other countries brought into the limelight the figure of the chemist Xu Guangxian (1920-2015)[58], the scientific father of Chinese rare earth developments. His work was vital for the progress of the rare earth industry in China and the training of scientists to become experts in the field of those metals. Once again, there is a US connection in the history of rare earths with nuclear fission (and armaments). Xu went to the US (1948) where he obtained a Doctorate in Physical Chemistry at the University of Columbia. In 1951 he returned to the new People's Republic of China to

58 GAO, S., «Rare earth chemistry - in memory of Professor Xu Guangxian on the centenary of his birth», Inorganic Chemistry Frontiers, DOI: 10.1039/d0qi90084b, 2020.

take up a post at the University of Peking. Five years later he was running the Radiation Chemistry Department that was taking part in the Chinese nuclear weapons programme, where he specialised in separating and extracting uranium for nuclear fuels. During the Cultural Revolution he was accused of espionage and sent to a labour camp (1969-1972). After Mao's death and the coming of Xiaoping, Xu was given back his university post, where he focused on rare earths. He then proceeded to carry out theoretical, experimental and industrial research into the separation of these metals, completing a counter current extraction process which considerably reduced the time required to extract the metals and the cost of doing so. In 1986, Xu founded the Research Centre of Rare Earth Chemistry, and three years later, he was the key person in setting up the State Key Laboratory of Rare Earth Materials Chemistry and Applications. Until his death, Xu was a scientist famous the world over for his expertise in the field of rare earths.

Chinese domination: Baiyun-ebo mine

As was the case with the Mountain Pass Mine earlier, the history of the Baiyun-ebo Mining District exemplifies the developments made in rare earth mining since then. This open cast mine covers 48 square kilometres in the Chinese Autonomous Region of Inner Mongolia, about 150 kilometres to the north of the City of Baotou, whose economy revolves around iron and steel. The rare earth mineral is transported to Baotou for processing. Iron deposits were discovered there in 1927 and rare earths in 1935. Minerals have been extracted since 1957, including the resources used at the Nuclear Fuel Material Plant 202 in Baotou, which played a key role in manufacturing the first Chinese atomic bomb detonated in 1964. Baiyun-ebo has reserves amounting to approximately 1,500 million tonnes of iron (carbonates and oxides) and 1 million tonnes of niobium (oxides). The zone also contains 48 million tonnes of rare earths (monazite and bastnäsite), which is to say that they are predominantly light rare earths. They are to be found in a series of veins and dykes as a result of hydrothermal replacement of dolomite. It is the largest, rare earths mine on the planet, in terms of both production and reserves, which has enabled the China Northern Rare Earth Group High-Tech Co Ltd, owner and operator of the Baotou processing facilities to be the world's largest supplier of rare earths. Apart from Baiyun-ebo, which has 83% of all Chinese deposits, there are the Daluxiang and Maoniuping Mines (which are second in light rare earths output in China) in the Province of Sichuan[59]; in many ways, their deposits are similar to those at Mountain Pass as is the case with their content in bastnäsite and barium. There are other mines in the south-east of the country[60], in the provinces of Jiangxi (discovered in 1969), Hunan, Fujian and Guangdong and in the Autonomous Region of Guangxi Zhuang. The deposits appeared after the weathering of granite and concentration through adsorption of ions on clays, making them easy to mine. It is estimated that there are one million tonnes of rare earth elements that are very important because they are rich in content of the heavy rare earth type, accounting for 80% of the world's deposits.

The prodigal finding of rare earths in China did not go unnoticed to the country's governors. It was in 1992 that the former President Deng Xiaoping uttered his famous sentence: «the Middle East has oil, China has rare earths»[61]. Nine years after, President Jiang Zemin continued along the same lines, «Improve the development and application of rare earth, and change the resource advantage into economic superiority»[62]. The development started by Xiaoping in 1976 has been followed by subsequent Presidents as can be seen in Table 4. The rare earths mined in China are one of the ways in which China can exert its geopolitical influence on an international level. One of the country's targets for 2025 is to become the world's top technological research & development power for the rare earth industry. The Chinese are proceeding towards this goal with a long-term strategy. Moreover, although the deregulations that took place during the era of the US President Ronald Reagan and the English Prime Minister Margaret Thatcher are normally treated separately from the Xiaoping reforms, the former played a fundamental role in reorganising the

[59] WANG, D. *et al*., «A Special Orogenic-type Rare Earth Element Deposit in Maoniuping, Sichuan, China: Geology and Geochemistry», Resource Geology, 51: 177-188, 2001.

[60] VONCKEN, J.H.L., «The rare Earth elements, An introduction». SpringerNature, Basilea, pages 43-45, 2016.

[61] HUI, M. «How China built up its dominance in rare earths». Quartz (October 30, 2020). https://qz.com/1924282/how-china-became-dominant-in-rare-earths/#:~:text=Because%20of%20their%20uses%20in,%2C%20China%20has%20rare%20earths.%E2%80%9D Consultation date 18/02/2021.

[62] HURST, C. «China's Rare Earth Elements industry: what can the West learn?» Institute for the Analysis of Global Security (IAGS), 2010.

global economy and the birth of the Chinese monopoly over rare earths[63]. In the 1990s, thanks to the Baiyun-ebo Mine, Chinese supplies of rare earths were the cheapest because they were a by-product of iron ore extraction, the labour costs were lower and the environmental legislation was permissive. China plunged the prices and managed to exclude its competitors from the rare earth market, attaining such a predominant position that it nearly managed to monopolise the market.

Crisis and current situation

China had achieved such a predominant situation on the rare earth market because of its mineral deposits and price policy. At the turn of the century, it not only produced rare earths already separated at the plants it had constructed in China to process the minerals, but it had also opted for preparing end products on its own territory such as magnets, electric motors, computers, batteries, telephones, etc., that is, products of high economic value[64]. To develop its industry, it offered firms and foreign capital very favourable terms and conditions. Attracted by low domestic prices and an abundant supply, they were installed in a duty-free zone of Baotou with 120 square kilometres of land for foreign industry. That city went from being the Chinese capital of the rare earths industry, to being the international capital. Although the Baiyun-ebo Mine is in the middle of the desert, the city lies on the banks of the Yellow River, which provides all the water needed for processing the ores and for the industrial processing of manufactured products. Baogang Steel and Rare Earth, an industrial complex the size of a city is in Baotou. In 2014, five firms[65] were processing annually 73,500 tonnes of rare earth. This growth at the expense of Western industrial dynamism, has left a major gap in rare earth mining, industry and research in other countries. Globalisation and cost reduction had made it profitable for companies to relocate. In this respect in the US, Abraham admits with regret that «the Unite States is losing the expertise to develop its own resources and allowing future tech-

[63] KLINGER, Note 48, p. 104.

[64] GESCHNEIDER, K.A. «The rare earth crisis – the supply/demand situation for 2011-2015». Mater Matters, 6: 32-41, 2011.

[65] *Baotou Feida Rare Earth Co., Baotou Jinmeng Rare Earth Co., Baotou Hongtianyu Rare Earth Magnets Co., Wuyuan Runze Rare Earth Co. and Xinyuan Rare Earth Hi-Tech & New Material Co.*

nological advances to go to other countries»[66]. The French lawyer and journalist Pitron is even more pessimistic, admitting that «French mining culture is dying»[67].

In 2007, China began to impose restrictions on rare earth exports. It is the biggest exporter of them and also their biggest consumer. It wanted to (and wants to) save them for its own domestic market. In 1998, it introduced a licencing system and imposed an export quota for rare earth products by setting an export quota that amounted 65,600 tonnes per year in 2005. The following year it imposed a 10% export duty on rare earth metals and oxides. In 2009, the export quota fell to 50,145 tonnes and a year later the control was even more stringent: the sale tariff for other countries was raised to 15% (neodymium 25%) and it only recognised 32 exporters as being entitled to export rare earths[68]. The trading situation was tense, but an incident in the China´s Sea aggravated it still further. The price of rare earth elements rocketed on the world market. It was the 2009-2013 Crisis[69].

There is a group of eight small islands in the East China´s Sea, known as Senkaku in Japan, Diaoyu in China and Diaoyutai in Taiwan, which Japan incorporated into its territory in 1895. After a UN Report was published in 1968 revealing the presence of major energy resources in the archipelago's territorial waters, the Chinese and Taiwanese Governments claimed ownership of them. In this way, nationalist activists from the three countries have been involved in incidents. On 7 September 2010 there was another incident[70], this time a Chinese trawler was boarded by a Japanese coastguard patrol boat, what led to a serious diplomatic incident when the trawler was detained and taken to Japan. There, all the crew members were released except the Captain as he was to be prosecuted. Although China had not officially declared an embargo, as from 22 September a wave of anti-Japanese protests and demonstrations prevented rare earth shipments being sent to Japan. Rare earths were

66 ABRAHAM, Note 31, p.211.

67 PITRON, G., «La guerra de los metales raros». Ediciones Península, Barcelona, p. 209.

68 CHEN, Y., ZHENG, B., «What Happens after the Rare Earth Crisis: A Systematic Literature Review». Sustainability, 11, 1288, 2019.

69 VONCKEN, Note 60, pages 112-113.

70 REINHARD, D., «The Senkaku/Diaoyu Islands territorial dispute between Japan and China», UNISCI Discussion Papers, 32: 1696-2206, 2013.

now playing a direct role in geopolitics! This was to be the first embargo during the energy and digital transition. Japan imports from China, 90% of the metals it requires for its high-tech products. The diplomatic incident was over by the rapid release without charges of the captain of the trawler *Minjinyu 5179*. Despite all of this, the «embargo» was enforced for Japan until mid-November and was also extended to the USA and the EU. The situation was overcome but it caused considerable alarm among the consumers of those metals and their respective nations. That same year, the EU Government published a report on commodities that were vital for the European high-tech industry and the lack of security over their supply. Out of the fourteen commodities mentioned[71] rare earths were considered to be most at risk. A similar report was issued by the US Energy Department[72], analysing the role of rare earth metals in the clean energy economy. The USA admitted that it was vulnerable where the following seven elements for its military equipment were concerned: dysprosium, erbium, europium, gadolinium, yttrium, neodymium and praseodymium.

In 2011, the rare earth crisis reached its peak when prices, which had been stagnating since 2009, increased disproportionately. Indeed, prices, which had been rising by an average of 3.7% per year[73] between 1990 and 2009, suddenly rocketed[74]. Cerium rose from 4.5 US$/kg in 2009 to US$ 158/kg in 2011, neodymium rose from US$ 14/kg to US$ 318/kg, dysprosium from US$ 100/kg to US$ 2,510/kg, europium from US$ 450/kg to US$ 5,870/kg and terbium from US$ 350/kg to US$ 4,410/kg. The following year, in 2012, prices fell by 23-76% and continued to drop to values that doubled or tripled the pre-crisis prices, although in 2016 europium and terbium remained above US$ 1,600/kg. Unlike the prices for other metals, rare earth prices are not accessible because there is no extensively used public exchange. They are particularly susceptible to the movements on the Chinese market and many transactions are carried out directly between the purchaser and the seller, who reach an agreement

[71] European Commission, «Presentation of a list of 14 essential mineral commodities», MEMO/10/263, 2010.
[72] U.S. Department of Energy, «Critical materials strategy», December 2010.
[73] ECORYS, «Mapping resource prices: the past and the future», Final Report, European Commission - DG Environment (ENV.G.1/FRA/20410/0044), 2012.
[74] CHARALAMPIDES, G. *et al*., «Rare Earth Elements: Industrial Applications and Economic Dependency of Europe». Procedia Economics and Finance, 24: 126-135, 2015.

about the amounts. Moreover, heavy rare earth elements such as dysprosium and terbium have cash prices that vary depending on whether the Chinese frontier with Burma (Myanmar) is open or closed, given that the supply of these low-production elements decreases rapidly. In June 2020, the price of europium was US$ 285/kg and terbium was US$ 831/kg. There are specialist companies that, on payment, offer their periodical evaluations of this market.

In 2009, the US, the EU and Japan lodged complaints against China before the World Trade Organisation (WTO) for restricting rare earth exports. Since 2001, China has formed part of this supranational organisation that imposes a set of trading rules on its member countries. In mid-crisis they once again asked for a solution to the complaints submitted three years before. In 2014, the WTO ruled[75] against Chinese export quotas for rare earths. In 2015, after this failure, China cancelled the export quotas and the export tariff, and began to enforce the rare earth export licence. It is determined to utilise its own resources and to employ its citizens to obtain rare earths and to manufacture high tech devices. At present, the trade war between the USA and China is adding yet another complication to the rare earths sector.

The main consequence of the crisis was that the countries that are the biggest, rare earth consumers admitted that they were totally dependent on China. Therefore, in response to a potential scarcity situation they began the quest to find alternative sources, following three different paths and giving their backing to the firms involved: new mines were exploited, abandoned mines were reopened and the hunt for new reserves began all over the planet. Production is now more balanced. China, by extracting 130,000 tonnes per year (without including illegal mining, which in 2011 was estimated at 20% of the official figure) and pursuing its price policy, managed to control 97% of world production in 2010 (Table 5). In 2019, the percentage figure fell to 62%, as eleven countries appeared on the scene as the mining market expanded (Table 5).

[75] WTO, «China-Measures related to the exportation of rare earths, tungsten, and molybdenum», WT/DS431/AB/R • WT/DS432/AB/R • WT/DS433/AB/R, 2014.
WTO Appellate Body rules against Chinese restrictions on access to rare earths and other raw materials. https://ec.europa.eu/commission/presscorner/detail/en/IP_14_912 Consultation date 25/01/2021.

Reserves	Nation	2019 (%)	2015	2010	2005	2000	1995
44000000	China	132,000 (61.97)	105,000	130,000	98,000	70,000	30,000
14000000	USA	26,000 (12.20)	4,100			5,000	28,700
?	Myanmar	22,000 (10.32)					
3300000	Australia	21,000 (9.85)	10,000				3,000
6900000	India	3,000 (1.41)	1,700	2,700	2,700	2.700	2,500
12000000	Russia	2,700 (1.27)	2,500			2,000	6,000
?	Madagascar	2,000 (0.94)					
1100	Thailand	1,800 (0.84)	760		2,200		150
22000000	Brazil	1,000 (0.47)	880	550		1.400	400
22000000	Vietnam	900 (0.42)	200				
50000	Burundi	600 (0.28)					
124251100	TOTAL	213,000 (99.97)	125,140	133,250	102,900	81,100	70,750

Table 5. List of the eleven biggest producing countries of rare earths, with their mines in 2019 and their evolution since 1995. The world reserves are estimates, no data were available for Myanmar and Madagascar. Units are given in metric tonnes.
Based on data from the Mineral Commodity Summaries, U.S. Geological Survey.

China produces 132,000 tonnes per year from a world total of 213,000 tonnes per year of rare earths extracted (Table 5). It produces 20,000 tonnes more than in 2018![76] In China production increased by 10%, whereas in the US it rose by 44%. Australia and Burma have exceeded 20,000 tonnes per year. The huge Mount Weld Mine has been operating in Australia since 2013 (the mineral concentrate goes to a plant in Kuantan, Malaysia, for processing), and it could come to be the biggest source of rare earths outside China. The situation is complex. The US still imports from China 80% of the rare earths it consumes, and China is the main client of Burma. However, Burma has closed its frontier between the two countries because of territorial disputes,

[76] U.S. Geological Survey, «Mineral Commodity Summaries», 2020.

suspending rare earth exports[77]. The «Autonomous State» of Wa in Burma, lying on the border with China, is not recognised either by the Burmese Government or by any other international bodies, except China. The minerals extracted there come from two mines where rare earths have accumulated by adsorption of ions on clays and they contain high concentrations of dysprosium and terbium (32% of the world production). They are an appealing source for the Chinese refineries given that they are commercialised at relatively low prices by cheap labour and with deficient environmental protection. Other countries, such as Russia, have been extracting rare earths for years, but their production figures do not exceed 3,000 tonnes a year. There are also other countries that extracted in the past, such as India or Brazil, that have now reopened their old mine workings, and there are also the newcomers, who are mining for the very first time, namely Madagascar, Thailand, Vietnam or Burundi. The eleven nations mentioned above were the main producers of rare earths in 2019 (Table 5).

Critical and strategic elements

The demand for rare earth elements has been growing steadily, at approximately the same pace as production (Table 5) which doubled between 1995 and 2010, and will do likewise in 2020. These metals have become «critical» for industry and strategic for nations. Any chemical elements or minerals are considered to be «critical» if their scarcity would damage a country's economy because they are essential for that country's technological applications. Limitation is caused when there is no replacement and risks arise because the supply[78]:

a) depends on the price, as was the case during the aforementioned 2009-2013 rare earth crisis;
b) depends on the time, the fifteen elements consumed by the computing industry in the 1990s, not all critical, have increased to some sixty at present, including most of the rare earth elements;
c) depends on the technological context. What is essential for one kind of industry may not be for another and it may vary from one country to another on the basis of their needs;

[77] ROSKILL, «Rare earths: Myanmar's border to China recloses». https://roskill.com/news/rare-earths-myanmars-border-to-china-recloses/ Consultation date 25/01/2021.
[78] PREGO, Note 2, pages 109-111.

d) depends on imponderable occurrences such as the COVID-19 pandemic; according to the Global Times[79] (the Chinese Communist Party's emblematic newspaper) rare earth exports plunged by 26.7% year-on-year in the first eleven months of 2020, because in Ganzhou, where approximately 70% of the world's rare metals are processed, they were working in February at 20% of their capacity due to the outbreak, which affects exports to the USA, Japan and Europe[80];
e) in the particular case of rare earth elements, there is a «problem of balance»[81] as they are mixed in different proportions depending on the mineral, when an element is adjusted to its market demand, others are obtained in excess, which can put up their price owing to storage cost. On the contrary however, if production is adapted to the demand for the excess, a scarcity of the former is generated. Neodymium and dysprosium are the elements that are generally most in demand, whereas cerium, gadolinium, holmium, ytterbium, lutetium praseodymium and thulium are produced in excess and are stored[82].

The globalisation of the economy has involved industry, and with it trading in chemical elements and their minerals. They include those that are essential from a military perspective. They are the ones referred to as «strategic», whose domestic production cannot meet the demand made on them by the military industry. In 2012 the US military industry accounted for 5% of the rare earths consumed in the country. The US Department of Defence[83] admitted that it was vulnerable where certain rare earth elements were concerned, because they were strategic for their military equipment and recommended stockpiling yttrium and dysprosium in 2013 and europium in 2015. Strategic elements/minerals will always be critical but not critical elements will not always be stra-

[79] GT Staff, «Rare-earth exports plunge in first 11 months: Chinese customs», Global times (2020/12/7). https://www.globaltimes.cn/content/1209248.shtml Consultation date 25/01/2021.

[80] XUANMIN, L, «China's rare earth exports drop 20-30%, crippled by COVID-19 outbreaks abroad», Global Times (2020/5/14). https://www.globaltimes.cn/content/1188392.shtml Consultation date 25/01/2021.

[81] VONCKEN, Note 60, p. 109.

[82] BINNEMANS, K. *et al*., «Recycling of rare earths: a critical review», Journal of Cleaner Production, 51: 1-22, 2013.

[83] GAO, «Rare Earth materials: developing a comprehensive approach could help DOD better manage National Security risks in the supply chain». Report to Congressional Committees, 2016.

tegic. Publications sometimes confuse the two terms in usage. The world reserves of those elements/minerals whose supply in times of war would not cater for a State's minimum requirements are highly sought-after, and every industrialised country has its own list. The critical and strategic elements club has come to form part of geostrategy and world geopolitics.

The EU considers to be critical, those materials that are not only of major economic importance but are also affected by a supply security risk. There are 20 such materials from a list of 54 potential materials: antimony, beryllium, borate, chrome, cobalt, coke coal, elements in the platinum group, rare earth elements, fluoride, gallium, germanium, natural graphite, indium, magnesite, magnesium, mineral phosphate, niobium, silicon metal and wolfram. The EU does not include scandium[84] in the list of rare earths, but it does include yttrium. The criticality can be valued in detail; it is the heavy rare earths (from europium to lutetium, plus yttrium), followed by the light ones (from lanthanum to samarium) that the EU[85] considers to be at greatest risk where supply is concerned, supply being considered in the context of their potential for replacement, the rate at which they can be recycled, mining production and governance (according to the World Governance Index). Each member of the EU has its own list, which may or may not be the same as the common list. However, they all agree when it comes to the rare earths, as do the following technologically developed nations: Japan, South Korea and Australia, apart from China and the USA. Moreover, the importance of rare earth is increased by the fact there is a sharp growth in their demand, 8% per year. The following five rare earth elements are indicated as being both important and at risk where supply (2015-2030) is concerned[86]: dysprosium, europium, yttrium, neodymium and terbium.

The EU imports 99% of its heavy rare earths and 87% of its light rare earths from China. The risk involved in this dependence has led to different paths being forged in the quest for supplies. Accord-

[84] Scandium production is limited, about 15-20 tonnes per year, albeit continual on the increase, keeping pace with demand; its main applications are alloys with aluminium (aerospace industry, sports equipment), lasers in odontology and high-intensity discharge lamps (price in 2019: in lingots US$ 134/gram; as oxide US$ 5/gram).

[85] EU Ad-Hoc Working Group on raw materials, «Report on critical raw materials for the EU», European Commission, 2014.

[86] MCLEOD, C.L., KREKELER, M.P.S., «Sources of Extraterrestrial Rare Earth Elements: To the Moon and Beyond», Resources, 6, 40, 2017.

ing to recent estimates, there are rare earth reserves (Table 5) in China (about 44 million tonnes), followed by Brazil and Vietnam with around half that amount, then the USA and Russia, with one third of the Chinese estimate and, after that, a series of countries that are augmenting their exploitation activity. An approximate estimate of total world supplies puts the figure at around 124 million tonnes of rare earths (i.e., oxides of their elements: Rare Earth Oxides, REOs). It has also been estimated that, if these supplies were to be added to those resources not yet discovered, reserves would be large in relation to the expected demand, and may be sufficient for 900 years. Bastnäsite and monazite minerals make up the highest percentage of rare earth resources, there being considerable quantities of monazite in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand and the USA. Mining operations are expected to get under way in Greenland (the Llimaussaq complex: uranium, rare earth elements and zinc), Zambia (Nkwombwa Hill), Canada (Hoidas, Thor, Stange and Misery Lakes deposits), South Africa (Pilanesberg open cast complex and the reopening of Steenkampskraal). It must not be forgotten that it may take up to fifteen years from the moment deposits are discovered until they can actually be exploited commercially, which means that there can be no swift response to shortages.

Africa is a combat zone in this geostrategic «war» to obtain supplies in the future or to control them now. Javier Molina Acebo[87], member of the Board of the EdV-ESIC Business & Marketing School, considers that «arms from the Second World War are the modern day bits». In his opinion, wars are no longer fought «from an aeroplane, but with technology» and it is the rare earths that provide the support for the technology industry. In this sense, looking to Africa and remembering that «the Chinese are the owners of Angola, that it is exchanging raw materials for civil development». China has already approached the nations of Africa to exploit their rare earths potential. It uses their international debt to offer financial rescues in exchange for access to their rare earth deposits[88].

[87] De QUIROGA, C., «Las tierras raras, posible baza de China en la guerra comercial», ABC Economía (22/05/2019). https://www.abc.es/economia/abci-tierras-raras-posible-baza-china-guerra-comercial-201905220138_noticia.html Consultation date 25/01/2021.

[88] FERREIRA, G., CRITELLI, J., JOHNSON, W., «The Future of Rare Earth Elements in Africa in the Midst of a Debt Crisis», Eunomia Journal (Aug. 15, 2020). https://www.civilaffairsassoc.org/post/the-future-of-rare-earth-elements-in-africa-in-the-midst-of-a-debt-crisis Consultation date 25/01/2021.

European Union's response to the crisis

In 2011, during the rare earths supply crisis, the EU drew up a list of 14 raw materials. In 2014, it rewrote the list and increased the number to 20. By the time it had completed its latest update the number had grown to 27. On all these lists, both light and heavy rare earths posed the greatest supply risk to the EU. Once the critical elements had been identified, the EU promoted and partially financed the Project EURARE (European Rare Earth Element; 2013-2017) with nine million Euros (65% of the total). The project was set the basis for «the development of a European Rare Earth Element (REE) industry. Establishment of an REE value chain in Europe would safeguard the uninterrupted supply of REE raw materials and products crucial for sectors of the EU economy (including automotive, electronics, machinery and chemicals) in a sustainable, economically viable and environmentally friendly»[89]. The map prepared by EURARE[90] shows 76 rare earth beds and deposits in Europe (excluding Russia and including Turkey). Seven of them are resources, i.e., deposits that have been explored in sufficient detail to obtain good estimates. They lie in Scandinavia (Fen in Norway and in Sweden Norra Kärr and Olserum), Greenland (Sarfartoq, Kvanefjeld, Kringleme and Motzfeldt) and Germany (Storkwitz). Europe is attaching special importance to Greenland[91] as a main supply in the future. This autonomous region belonging to Denmark is an appealing source of rare earths. The Kvanefjeld Project, led by the Australian company Greenland Minerals, in which China's Shenghe Resources has a shareholding, aims to supply 25% of the world demand. There is another option, in Sweden, smaller but nevertheless of interest because it exploits heavy rare earths. The Norra Kärr complex (mineral eudialyte), discovered in 1906, is currently Europe's most promising project and is being run by Tasman Metals Ltd[92]. Taken as a whole,

[89] «The main goal of the EURARE project was to set the basis for the development of a European REE industry that will safeguard the uninterrupted supply of REE raw materials and products crucial for the EU economy industrial sectors, such as automotive, electronics, machinery and chemicals, in a sustainable, economically viable and environmentally friendly way». http://www.eurare.org/ Consultation date 18/02/2021.

[90] «REE resources, deposits and occurrences in Europe recognised by the EURARE Project (2013-2017)». http://oryktos.blogspot.com/2018/03/europes-ree-eurare-project-is-completed.html Consultation date 25/01/2021.

[91] PAULICK, H., ROSA, D. AND KALVIG, P., «Rare Earth Element projects and exploration potential in Greenland», MiMa rapport 2015/2, 2015.

[92] VONCKEN, Note 60, p. 40.

EURARE considers that these seven deposits can guarantee EU supplies for decades. These types of mining activities require a lot of investment, so it is advisable to concentrate exclusively on Greenland and Sweden, as suggested by Christopher Ecclestone, a mining specialist working with the New York investment bank Hallgarten & Company: «Europe ought to concentrate on one or two mines and on recycling a lot»[93].

In Spain, the map refers to a deposit in Mulas and two occurrences, one of which is associated with alkaline igneous rocks in Galiñeiro mountain range, and another in sandbanks located in the «Rambla de las Granatillas». A recent review detected five,[94] lying in «Sierra del Galiñeiro» (Galicia), «Campo de Montiel» (Ciudad Real), «Rambla de las Granatillas» (Almeria), «Río Cua» (Asturias) and Fuerteventura Island (Canary Isles). The «Sierra del Galiñeiro»[95] is a 10-square kilometres geological complex, described by a Dutch geologist in 1966. It is composed of alkaline and peralkaline gneisses with minerals rich in rare earths (bastnäsite, fergusonite, monazite, thorite, xenotime, allanite, thorianite and zircon), whose erosion transports rare earths and thorium into the sediments of the Vigo Ria[96] and the River Miño[97]. In 2013, a mining project was thwarted by technical difficulties and local social pressure. There is a monazite alluvial sandbank in «Campo de Montiel» covering an area of 2.34 square kilometres with 30 thousand tonnes of material with a high content in neodymium, praseodymium and europium. It was found by the company Quantum Mineria, whose Matamulas Project was rejected in 2019 after receiving a negative environmental impact statement because it affected the habitat of the imperial eagle, the lynx and the little bustard[98]. The other three were a) the alluvial deposits at Granatilla, to the south of the volcanic complex of «Hoyazo de

93 https://elpais.com/politica/2015/05/10/actualidad/1431274081_028653.html Consultation date 25/01/2021.

94 MORANTE GUTIÉRREZ, M., «Estudio de prefactibilidad de un aprovechamiento de tierras raras en España». Universidad de Cantabria, Santander, pages 43-46, 2019.

95 FLOOR, P., «Petrology of an aegirine-riebeckite gneiss-bearing part of the Hesperian Massif: The Galiñeiro and surrounding areas, Vigo Spain». Leidse Geologishe Mededelingen, 36: 1-204, 1966.

96 PREGO, R. *et al*., «Rare earth elements in sediments of the Vigo Ria, NW Iberian Peninsula», Continental Shelf Research, 29: 896-902, 2009.

97 PREGO, R., *et al*., «Lanthanides and yttrium in the sediments of the lower Miño River (NW Iberian Peninsula). Imprint of tributaries», Journal of Soils and Sediments, 19: 2558-2569, 2019.

98 BURKHALTER, E., Personal Communication, 2019.

Níjar», which were mined for the garnet and contain light rare earths and thorium[99]; b) The carbonatites in the Fuerteventura Basalt Complex have a greater content in light rare earths in exploitable amounts[100]; and c) The River Cua, for which there is no accurate information. Apart from these three places already identified, new deposits have also been found on Gran Canaria Island[101] containing a volume of light rare earth elements and yttrium covering about one thousand cubic kilometres. There are further deposits on the border between Salamanca and Zamora, in the zone known as «Domo del Tormes», where considerable proportions of lanthanum and cerium have been detected in biotite porphyry granite[102].

Another option is to recycle rare earth elements. It is a secondary alternative whose purpose is to prevent contamination or to fulfil strategic resource requirements, more than to obtain genuine economic benefits in the industrialised countries. Recycling is very low, 1%, due to an absence of technological challenge, inefficient collection and a lack of incentives[103]. Importance is being increasingly attached to this question and extensive reviews are available on the subject[104] that can be referred to. The problem faced by the industry is that recovering rare metals is a very expensive process, the cost currently being greater than their value[105]. They are generally waste materials from permanent magnets, lamps, screens, computing material and rechargeable batteries. In EU only fluorescent tubes, Ni-MH batteries and magnets are recycled on a commercial scale. For the last two, the European Project REE4EU[106] developed on an industrial scale, a

[99] LÓPEZ-RUIZ, J., «El campo neógeno del SE de España», Enseñanza de las Ciencias de la Tierra, 7.3: 244-253, 1999.

[100] MANGAS, J. *et al*., «Minerales de tierras raras en las carbonatitas del Complejo Basal de Fuerteventura (Canary Isles)», Geogaceta, 20: 1511-1513, 1996.

[101] MENÉNDEZ, I. *et al*., «Distribution of REE-bearing minerals in felsic magmatic rocks and paleosols from Gran Canaria, Spain: Intraplate oceanic islands as a new example of potential, non-conventional sources of rare-earth elements», Journal of Geochemical Exploration, 204: 270-288, 2019.

[102] LÓPEZ PLAZA, M., GONZALO CORRAL, J.C., «Caracterización geoquímica de las anatexitas del Domo del Tormes (provincias de Salamanca y Zamora)», Revista de la Sociedad Geológica de España, 6: 113-128, 1993.

[103] BINNEMANS *et al*., Note 82.

[104] BUSTILLO REVUELTA, M., RUÍZ SÁNCHEZ-PORRO, J., «Tierras raras: geología, producción, aplicaciones y reciclado», Fuello Editores, Madrid, pages 353-403, 2019.

[105] PITRON, Note 67, p. 76.

[106] REE4EU «Project: Rare Earth Recycling for Europe». https://www.ree4eu.eu/the-project/ Consultation date 25/01/2021.

rare earth alloy extraction method for magnet production. Price rises have made recycling more profitable; material is sent to countries where labour is cheap and environmental legislation is lax. The US exports 80% of its electronic waste to Asia and the EU sends 1.3 million tonnes per year to Africa (Ghana) and Asia (China, Philippines, India and Vietnam). As the chemist Keith Veronese points out[107]: «[in] the Third World [dirty recycling] is disturbing post-apocalyptic. Venturing into mountains of discarded monitors, desktop towers, and refrigerators, children and teenagers fight over sun-and-rain-exposed electronic parts in search of any metals – even ones the First Word discards with every can of soda – for possible resale».

At present, greater importance is being attached to «urban mining», i.e. recycling of domestic materials, and more attention is being paid to industrial wastes such as phosphogypsum and aluminium red mud. Although some devices are relatively poor in rare earths, thus making their recovery difficult, if huge volumes of material are added together a large quantity can be obtained and such devices are becoming a potential source of neodymium, praseodymium, samarium, dysprosium, cerium, europium and yttrium. They can be separated using hydrometallurgical processes[108], which are less costly and hardly cause any pollution.

US response to the crisis

At the end of the rare earths crisis, in 2013, US had reacted like the EU, by setting up a Critical Materials Institute (CMI)[109], an energy innovation centre run by the Ames Laboratory with a holistic approach to the critical materials cycle. Self-designated as the Manhattan-type Project because of its dimensions (four national laboratories, seven universities and 10 industrial partners); project includes scientific research, innovation in engineering, manufacture and process improvements. It is the US's attempt to reduce its vulnerability in the field of rare earths. In

[107] VERONESE, K., «Rare», Prometheus Books, New York, p. 143, 2015.

[108] JYOTHI, R.K. *et al*., «Review of rare earth elements recovery from secondary resources for clean energy technologies: Grand opportunities to create wealth from waste», Journal of Cleaner Production, 267: 122048, 2020.

[109] *The Critical Materials Institute is a U.S. DOE Energy Innovation Hub led by Ames Laboratory, and supports early-stage research to advance innovation in U.S. manufacturing. CMI seeks ways to eliminate and reduce reliance on rare-earth metals and other materials critical to the success of clean energy technologies*. https://www.ameslab.gov/cmi Consultation date 25/01/2021.

her book which appeared in 2017, Victoria Bruce, a journalist with training in geology, states that «American technological prowess used to be unrivalled. But because of globalization, and with the blessing of the US government, once proprietary materials, components and technologies are increasingly commercialized outside the US.»[110]. Afghanistan could provide good mining support. In 2011 the United States Geological Service (USGS) had informed[111] about the largest, rare earth mineral deposits discovered under an extinct volcano in South-West Afghanistan. It estimated that the reserves could supply the whole world for 10 years. In this respect, James Kennedy, a rare earths expert and President of *ThREE Consulting*, wrote[112]: «Although this area is one of the most promising mineralised areas in the world, it is a shit sandwich… Yesterday, looks like a vehicle-borne IED wiped out many if not most of the Afghan mining and oil and gas personnel near Afghan Geological Survey and Ministry of Mines in Kabul…probably lost most of their senior geologists… Conclusion: forget about it….mining in this country will not happen in our lifetime…too corrupt and no infrastructure», so he declared that «American greatness comes from economic and technological leadership, not endless conflicts. This is an issue for American leadership».

The US response involves reopening the aforementioned Mountain Pass Mine, where light rare earths are extracted. As was the case with the EU in Europe, the USGS conducted an extensive survey[113] to find out what potential deposits could be extracted from USA territory. Bokan Mountain (Alaska) was found to have 5.3 million tonnes of rare earths, of which 40% were of the heavy kind, Bear Lodge (Wyoming) contained 550 thousand tonnes, Round Top (Texas) had 300 thousand tonnes and Elk Creek (Nebraska) proved to be rich in scandium (3,400 tonnes of its oxide). Amongst them, as the matter of heavy rare earths is a sensitive subject, the underground Bokan Mountain mine on

[110] BRUCE, V., «Sellout: How Washington Gave Away America's Technological Soul, and One Man's Fight to Bring It Home», Bloomsbury, New York, 304 pages, 2017.

[111] PETERS, S.G., «Summaries and Data Packages of Important Areas for Mineral Investment and Production Opportunities in Afghanistan», The USGS-TFBSO Afghanistan Minerals Project. U.S. Department of Defense, and the U.S. Geological Survey, 2011.

[112] KENNEDY, J., «Blackwater mercenaries go Off-World», 2017. https://www.linkedin.com/pulse/blackwater-mercenaries-go-off-world-james-kennedy Consultation date 18/02/2021.

[113] TRACY, B.S., «An Overview of Rare Earth Elements and Related Issues for Congress», Congressional Research Service, USA, 2020.

Prince of Wales Island (Alaska) seems to be the most suitable. There is a currently closed uranium mine in this mountain, which lies in and around the rare earth deposits. The Canadian firm Ucore[114] took over the concession in 2012 and expects to produce 375 tonnes of rare earth concentrates per day throughout the eleven years it plans to commercialise near the mine, applying its patented solvent extraction technology.

Another global option for supplying the scarce heavy rare earths is the Browns Range Mine (xenotime-Y), which covers 3,600 square kilometres in Western Australia. It is in a position to become the biggest producer of dysprosium (price in December 2020: US$ 244/kg) and terbium (US$ 958/kg) outside China. In 2018, with a view to checking its technical and economic feasibility, Northern Minerals Limited began producing rare earth carbonate at a pilot plant located inside the mine itself.

Japanese response to the crisis

Japan is a highly sensitive nation when it comes to restrictions imposed on rare earth elements, especially when this affects its automobile industry. For example, Toyota needs 10,000 tonnes of rare earths per year for its hybrid vehicles. One option Japan has turned to in order to overcome the scarcity problem is recycling. Firstly, it is recycling the catalytic converters that contain platinum, palladium, rhodium and cerium oxide deposited on aluminium and lanthanum oxide, so new catalytic converters can be manufactured. Secondly, in 2018, Toyota manufactured a new magnet[115] for electric motors that requires only half the amount of rare earths. It uses neither terbium nor dysprosium and replaces part of the neodymium with lanthanum and cerium, which are more abundant and cheaper. Other firms had already taken this path. In 2012, Nissan had developed a new electric motor with 40% less dysprosium and TDK had discovered a method for manufacturing magnets also with 50% less of that same metal[116].

114 UCORE, «Bokan Mountain Alaska: The highest grade heavy rare earth element Project in the United States of America», 2021. https://www.ucore.com/bokan Reference date 25/01/2021.

115 Toyota, «Toyota will reduce its use of critical rare earths by 50%, thanks to a new magnet for electric motors», 2018. https://prensa.toyota.es/toyota-reducira-el-uso-de-tierras-raras-criticas-un-50-gracias-a-un-nuevo-iman-para-motores-electricos/ Reference date 25/01/2021.

116 ZHOU, B. *et al*., 2016. Rare Earth Elements supply vs. clean energy technologies: new problems to be solved. Mineral Resources Management, 32: 29-44.

Apart from this specific area of industry, and as Abraham noted in 2015[117], «Japan is a little bit in flux at the moment. They do look at rare metals as the lifeblood of their economy and their manufacturing economy» and he continues, «they're less afraid to put money to ensure supply lines are strong, although that's faded a little bit. But they also invest a lot more in education and giving money to universities to focus on a lot of these materials».

The other path that emerged as a result of the 2009-2013 crisis was the search for the country's own rare earths. The Japanese Government aims to obtain more than 60% of its rare earth requirements without resorting to China. To achieve this, the main Japanese corporations carry out mining projects in cooperation with local companies in Australia, India and Kazakhstan. Japanese companies can rely on backing from their Government, which is establishing international associations in those same regions. Japanese dependence on imports is about to become a thing of the past, after the discovery, in 2011, of deep-sea mud with a high content of rare earth elements (hydrothermal iron oxyhydroxides and phillipsite) in the North Pacific. Geologists estimated that these were huge and very promising resources where an area of one square kilometre could yield one fifth of the world's annual consumption of these elements[118]. Later, in 2013, a Japanese campaign carried out on the deep-sea research vessel Kairei found a layer of mud 2-to 4-metres thick at depths ranging from 5,600 to 5,800 metres around the island of Minami-Torishima, within Japan's Exclusive Economic Zone (EEZ). These muds are very rich in both light and heavy rare earths, containing 0.66% heavy rare earths, i.e., 25 times more than the deposits in the south of China[119]. The island of Minami-Torishima, which is small (1.5 square kilometres) and isolated (there is no other land mass for a thousand kilometres in any direction) is 1,950 kilometres south-east of Tokyo in the North Pacific Ocean, and has belonged to Japan since 1898. The prospect of Japan becoming a nation rich in metal resources, in general, and rare earths, in particular, has become a reality with the discovery of these resources. A system is now being devised that will make it possi-

[117] Abraham, D., Kintisch, E., «The Rare Metal Age», Science & Diplomacy, vol. 4, no, 4, 2015.

[118] KATO, Y., *et al*., «Deep-sea mud in the Pacific Ocean as a potential resource for rare-earth elements», Nature Geoscience, 4: 535-539, 2011.

[119] IIJIMA, K. *et al*., «Discovery of extremely REY-rich mud in the western North Pacific Ocean», Geochemical Journal, 50: 557-573, 2016.

ble to recover them, together with a procedure for processing the minerals so they can be exploited in a short term. It is estimated that there are approximately 16 million tonnes of mineralised rare-earth sediments. An area of 105 square kilometres means 1.2 million tonnes of rare earths, amounting to 62, 47, 32 and 56 years of the overall annual demand for yttrium, europium, terbium and dysprosium, respectively[120]. The country's scientists believe that it will be possible to cater for the world's requirements for over 500 years!

The Japanese initiative has speeded up the search for similar marine deposits in all the oceans. Such deposits have been known to exist for over a century. Approximately 40 years ago, scientists began to find out about the origins, distribution and potential of these resources. Then the low prices of metals on the world markets dampened enthusiasm for mining the ocean depths until 2000, although research was never actually given up. Mining consortia from China, France, Germany, India, Japan, South Korea and Russia are continuing their attempts to exploit the seabeds that are richest in polymetallic nodules with economic potential[121]. They are mainly concentrated in three ocean regions: the Central Indian Ocean Basin, the Peru Basin and the Clarion-Clipperton Fracture Zone in the North-East Pacific. The deposits are composed of manganese nodules, ferromanganese crusts and polymetallic sulphides precipitated in the hydrothermal vents of the oceanic ridges. They lie beyond the 200-mile Exclusive Economic Zone, in international waters, so exploration and exploitation in those areas can be carried out by anyone. Known as «The Zone», it falls within the administrative scope of the International Seabed Authority (ISA)[122], established in 1994. Each consortium, through ISA´s organisation and abiding by the

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[120] TAKAYA, Y. *et al*., «The tremendous potential of deep-sea mud as a source of rare-earth elements», Scientific Records, 8, 5763, 2018.

[121] HEIN, J.R. *et al*., «Deep-ocean mineral deposits as a source of critical metals for high- and green-technology applications: Comparison with land-based resources». Ore Geology Reviews, 51: 1-14, 2013.

[122] *The International Seabed Authority (ISA) is an autonomous international organization established under the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and the 1994 Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea (1994 Agreement). ISA is the organization through which States Parties to UNCLOS organize and control all mineral-resources-related activities in the Area for the benefit of mankind as a whole. In so doing, ISA has the mandate to ensure the effective protection of the marine environment from harmful effects that may arise from deep-seabed related activities*. https://www.isa.org.jm/about-isa Consultation date 25/01/2021.

ISA's rules, contract a research plot covering less than 150 thousand square kilometres, and holds exclusive rights over that area for eight years. These new legal arrangements reveal the fact that a century ago, the oceans (71% of the planet) had no owners, but now 40% of that marine surface (28% of the planet) belongs to one country or another, 10% (7% of the planet) remaining in dispute. To express it another way, the «free» ocean has been reduced from 71% to 36%, i.e., it has been halved in favour of national and commercial interests. Some States now wish to extend their exclusion rights from 200 to 350 miles.

The emergence of underwater mining resources and the deposits lying in the Spanish Exclusive Economic Zone have been summarised and analysed clearly and in depth in an article published by the Spanish Geological Survey (IGME)[123]. That article points out that there are three geographical zones of great interest: the Gulf of Cadiz, the «Banco de Galicia», a seamount at 180 kilometres west Galician coast, and the underwater mountains close to the Canary Isles. The last of those three is the most outstanding. Defined as the Volcanic Province of the Canary Isles, it features a large number of underground hills and mountains, some of which are beyond the 200-mile limit. One such example is the underwater mountain Tropic (3.5 kilograms of rare earths per tonne of ferromanganese crust). Spain has been studying this zone and the surrounding seabed for many years[124], in order to provide documentation for the demand it submitted to the UNO in 2014 applying to extend the Canary Isles continental shelf to 350 miles. The ferromanganese crusts studied in the underwater mountains of the Canary Isles contain, amongst other metals, 0.4% rare earths.

A «rare» key piece in the energy puzzle?

Rare earth elements came to fully form part of our society in the 1960s, turning it into a high-tech society. At the beginning of that decade the Russian science historian Trifonov[125]

[123] MARINO, E. *et al*., «Llega la era de la minería submarina», Tierra y Tecnología, 49, 2017. https://www.icog.es/TyT/index.php/2017/05/llega-la-era-de-la-mineria-submarina/ Consultation date 25/01/2021.

[124] MARINO, E. *et al*., «Strategic and rare elements in Cretaceous-Cenozoic cobalt-rich ferromanganese crusts from seamounts in the Canary Island Seamount Province (northeastern tropical Atlantic)», Ore Geological Reviews, 87: 41-61, 2017.

[125] TRIFONOV, D.N., «The rare-earth elements», The MacMillan Company, New York, page 118, 1963.

stated, in an excellent review of the subject of rare earths, that «Rare-earth elements are a forgotten branch of inorganic chemistry» and predicted: «It would not be surprising if in the near future the rare-earth metals become just as common in science and industry as, for example, magnesium or aluminium are now». And that is what happened. In the past fifty years, rare earths have been dealt with in great detail from both viewpoints boosted by their applications, leading us to the Rare Earth Age. Although each one of the planet's inhabitants barely consumes 17 grams of rare earths a year, the world would be moving at a much slower pace without these scarce crumb-like bits of the Earth's crust[126]. Progress is constantly being made in this area. One only needs to glance through what is being published in scientific journals and then remember when these new devices first became available and how they are now making their contribution to alternative and renewable energy supplies. Once rare earths have been fully incorporated into our culture, and the above pages have been read, attention can be paid to answering the three questions that were asked about their relationship with energy. Are rare earths directly involved in energy production? Do they improve energy consumption efficiency? Do they provide means for making energy management easier?

The last question leads to the periodic table of chemical elements. Lanthanides are the only elements for which filling their seven «f» orbitals provide special magnetic and optical properties. After these, i.e., from hafnium to radium, the «f» orbitals are complete, and the radioactive actinides only repeat that filling for their «cousins». However, only four of them exist in nature, the rest being elements obtained artificially. The four are: actinium and protactinium (extremely scarces), thorium and uranium, which are not suitable for the lanthanide applications. They are unique among the chemical elements in our Universe. Together with scandium and yttrium, which are contained in the same minerals, they are irreplaceable in most technological applications. In the US, the USGS accepts this in its reports[127]: «Substitutes are available for many applications but generally are less effective». As in the case of Europe, the final report on the EURARE Project

126 PITRON, Note 67, page 106.

127 USGS, «Mineral Commodity Summaries 2020», U.S. Department of Interior & U.S. Geological Survey, 2020.

points out the following[128]: «For applications where substitutes have been identified the substitutes are generally critical raw materials themselves, or more expensive». Several elements, more onerous and less abundant, such as europium, terbium and dysprosium cannot be replaced, whereas with thulium, ytterbium and lanthanum, finding alternatives is difficult (only in 25% of the devices); with praseodymium, neodymium and samarium, in 60%, and for the rest of elements is possible in 37-40% of the cases[129]. It goes without saying that the conclusion «the outstanding efforts of materials scientists over the last few decades appear to have effectively decoupled substitution from price in many cases, because often no suitable substitute can be found no matter what price is offered without performance and function being seriously compromised». In potential replacements, means that rare earth elements can be regarded as irreplaceable in their military role, which makes them «strategic». In reply to the initial question, it can be stated that rare earths are essential for energy management in all control, communications and IT devices, because they make it possible to build-up pseudo-intelligent electrical grids, and they are also vital for other similar purposes in our current technological society.

Pursuant to the second question, rare earth elements are to be found in many items of equipment that reduce energy consumption. They are particularly important in two, lighting and magnets. The modern and increasingly utilised LED lights use less rare earth elements and also consume less energy, they last longer and their performance is 20% better than that of the phosphorescent tubes they are replacing. Magnet manufacture consumes a mix of neodymium (the primary application of its global production), praseodymium and dysprosium, as well as other elements utilised in fillers, such as cerium and gadolinium. These magnets have replaced the traditional ones in electronic devices in order to amplify radiofrequency signals, fans, hard disk reading heads, nuclear magnetic resonance imaging, speakers and headsets, electric motors, wireless tools, servomotors, synchronous motors, stepper motors or motors for electric and hybrid automobiles. Roskill's Rare Earths Outlook report[130]

[128] EURARE brochure, 2017. http://www.eurare.org/docs/EURAREbrochure_vfinal.pdf Consultation date 25/01/2021.
[129] GRAEDEL, T.E. *et al*., «On the material basis of modern society», PNAS, 2013. https://doi.org/10.1073/pnas.1312752110 Consultation date 25/01/2021.
[130] ROSKILL, «Rare Earths. Outlook to 2030», 20th Edition, 2020.

contains a detailed breakdown of the demand, assessing technological and industrial trends and their impact on the consumption of each element by end-use market. It predicts that by 2030 rare earth magnets will account for 40% of the total demand, i.e., almost twice the present percentage. As has already been pointed out (Figure 3), research into applications is taking place at an astonishing rate. The magnetic properties of rare earths in the manufacture of sustainable and efficient cooling systems and heat pumps, by making use of the magnetocaloric effect, are being examined. It is one of the best energy-saving solutions given that it allows for environmentally friendly cooling (it does not use gases that are harmful to the atmosphere), silent cooling (it has no moving parts) and consumes less energy (they are three times as efficient as the traditional solutions). As its feasibility with gadolinium has already been demonstrated, tests are now being conducted with prototypes using cheaper rare earth elements, on industrial cooling equipment, vehicle and building air-conditioning systems and cooling systems in supermarkets. This is just one of the many examples showing the great potential that rare earth elements have, perhaps their biggest contribution: «green» applications to reduce energy consumption.

Finally, rare earths play a role in different cases of energy storage and production. If one considers the three basic sources of energy on Earth: solar nuclear fusion (hydrogen and helium), nuclear fission (uranium thorium and potassium) in our planet, and gravity (tides), rare earths play an insignificant role: Promethium as a nuclear battery, or a secondary role: as a poison to reduce high reactivity in nuclear reactors. In both cases, there are other chemical elements that can be utilised as substitutes. As a result, they are replaceable. If one takes into account the energy sources coming from the gradients originated by the three primary ones on the Earth: mainly the intermittent sources (wind and solar), and the hydraulic and geothermal sources, the role played by rare earth elements is considerable, especially in the case of electric generators for wind turbines. Even so, dependence on rare earths can be reduced by manufacturing asynchronous or synchronous generators without permanent magnets, If no alternative solutions are forthcoming in the next few years, the wind sector could end up consuming 6% of the annual production of neodymium and over 30% of the annual production of dysprosium, because off-shore wind farms -one of the renewable technologies with the greatest expansion potential- are expected to reach a capacity of 120 GW. The European Commission estimates that by 2030 the EU will have an installed capacity of at least 60 GW of marine wind energy plus 1 GW of ocean energy, from the current 12 GW, and it is planned to reach 300 GW and 40 GW, respectively, of installed capacity by 2050[131].

At another aspect of energy: storage, rare earths play an interesting role in the fabrication of batteries, even if only small amounts of rare earths are used in the cathodes of Ni-MH batteries. Compared with the still expensive lithium-ion batteries, they will continue to be used. Experiments are being carried out in which hydrogen gas for vehicles is stored, and research is also being conducted pm an extended performance of solar cells[132] using ytterbium, as it absorbs the infrared light and sends it to erbium, which returns it as visible green light. Rare earths are valuable Energy Transition assets in the energy storage and production areas. It is to be hoped that they will play a greater part in energy generation and research must be conducted into increasing and improving their applications, if possible by putting to good use the surplus caused by the above-mentioned critical problem of balance in the production of rare earth elements.

Challenges to overcome

At present, two of the still unresolved challenges stand out from the rest. One of these is an environmental challenge and the other is geostrategic. They must always be approached with a comprehensive overview and we must invariably be concerned about our planet. On the one hand, rare earth elements must be used efficiently when developing a renewable energy and low-carbon economy. It is vital to have a suitable scientific policy when seeking solutions that enable each nation to achieve its own energy independence, adapting to its natural wealth. In this sense, Spain is no different, and great care must be taken to ensure that there is no loss of scientific and technical expertise due to a generation gap in passing on knowledge. Moreover, as

[131] EUROPEAN COMMISSION, «An EU strategy for making the most of renewable marine energy potential for a climatically neutral future», 2020. https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX:52020DC0741 Consultation date 25/01/2021.

[132] FAKHIM LAMRANI, A., «Rare-earth-doped TiO2 rutile as a promising ferromagnetic alloy for visible light absorption in solar cells: first principal insights», RSC Advances, 10, 35505, 2020.

ROBERS Jr., G., «Nanoparticle Breakthrough Could Capture Unseen Light for Solar Energy Conversion», 2018. https://newscenter.lbl.gov/2018/04/23/nanoparticle-breakthrough-solar-energy-conversion/ Consultation date 25/01/2021.

the prices of everyday pieces of equipment are constantly falling and their life cycle shortening, it is necessary not only to utilise resources efficiently, but also to change certain consumer habits and business models and to create a profitable supply chain where products are designed to be easily recycled or reused. Governments have to work more closely with research institutions and the technological industry in order to understand what the future demands for critical elements will be and to enhance their work. In an interview, Pitron[133] offers a way: «The only realistic solution I can see is the circular economy in which the economic growth is not proportional to the increase in the use of raw materials and energy. This will let us carry on growing while caring for the planet at the same time». All in all, this means trying to live simply and in moderation.

Environmental friendliness: preventing pollution

US domination of the rare earths market through its Mountain Pass Mine ended at the turn of the last century. In 1980, a mistaken classification of rare earths had disastrous consequences for its mining activities[134]. The Nuclear Regulatory Commission and the International Regulatory Agency subjected rare earth mining to the same regulations as the mining of thorium, a radioactive element that is wasted when certain rare earth minerals are processed. This, together with several incidents in which radioactive waste was spilt in the Mojave Desert, caused the US's rare earths mining industry to collapse and be moved to China. Pitron describes a similar sequence of events in France[135], where the French chemical industry Rhône-Poulenc*,* the owner of a plant in La Rochelle, was one of the top two rare metal firms. During the 1980s, it purified annually half the world's rare earths. After constant rumours in the press about radioactive pollution in the sea, the company moved the business to China, where in addition it was supplied with rare earths at a quarter the price of Europe. The contamination problem occurred again in China, this time on a much worse scale. The toxic waste generated when processing the mineral is disposed of a few

133 ALDAMA, Z., «Las energías renovables y las tecnologías digitales no son tan verdes», El País Economía, 2020. https://retina.elpais.com/retina/2020/02/14/innovacion/1581675324_297883.html Consultation date 25/01/2021.
134 MILLS, R., «How the US lost the plot on rare earths», 2019. https://www.mining.com/web/us-lost-plot-rare-earths/ Consultation date 25/01/2021.
135 PITRON, Note 67, pages 90-95.

kilometres from Baotou. About seven million tonnes a year are discharged[136] into the Weikuang tailings dam, which the locals used to refer to as «the rare earths lake». The dam was constructed in 1966, at the same time as the processing plants, which use several acid baths to extract the rare earths[137]. In 2005, Xu Guangxian expressed his concern in an official survey[138] into thorium as the cause of radioactive contamination in the Baotou zone and the Yellow River. The pond is twelve kilometres to the west of that city and ten to the north of the Yellow River. Approximately 150 million people depend on the river for their water supply, so radioactive contamination is a very serious problem. Ten thousand cubic metres of residual gas are generated to produce one tonne of rare earths, the residual gas containing sulphur dioxide, hydrofluoric and sulphuric acid and concentrated powder. Moreover, seventy-five cubic metres of acid wastewater and around a tonne of radioactive waste are also generated. All of this waste flows into the Weikuang tailings pond, which covers a surface area of twelve square kilometres and contains 150 million tonnes of tailings[139].

The contamination problem causes scepticism about green technologies and arouses doubts about the advantages of the energy and digital transition where health and the environment are concerned. It is absolutely essential to consider the complete extraction-application cycle for rare earth elements. Globalisation to obtain economic profit is amounting to a dichotomy with fake blindness. In the words of Pitron[140]: «Isn't there a tragic irony in the fact that the pollution no longer emitted in the urban agglomerations thanks to electric vehicles, merely appears in other areas, especially where the resources are extracted that are indispensable for the manufacture of such vehicles?». The challenge lies in finding ways to mine rare earth resources that are both economically and environmentally viable. It would appear that this challenge has been developed successfully in the USA projects involving the opening of mines on their territory, and the same seems to be the case in Aus-

136 AsiaNews.it, «China's dilemma: how to mine rare earths whilst protecting reserves and the environment», 2011. http://www.asianews.it/news-en/China%E2%80%99s-dilemma:-how-to-mine-rare-earths-whilst-protecting-reserves-and-the-environment-21039.html Consultation date 25/01/2021.

137 EJatlas, 2020. https://www.ejatlas.org/print/bayan-obo-world-biggest-rare-earths-mine-baogang-group-baotou-inner-mongolia-china Consultation date 25/01/2021.

138 HURST, Note 62.

139 EJatlas, Note 137.

140 PITRON, Note 67, p. 80-81.

tralia and the EU[141]. The EURARE Project has embarked on pilot schemes using technologies adapted to the type of mineral that is exploited in the EU and has done so in compliance with European legislation to protect the mining and industrial process environment where emissions and waste are concerned[142]. The environment is not a hindrance to guaranteeing the supply of rare earths in Europe or other continents. According to the British expert Goodenough[143] «the greatest drawback to guaranteeing the supply of rare earths in Europe is that companies find it difficult to make their activities profitable. There is great dependence on prices, which are determined by the investors' fluctuations on the Stock Exchange and the market equilibrium regarding supply and demand. It is advisable to receive State backing, at least initially».

The irony of all this is that thorium could be a profitable by-product from mining the rare earth minerals that contain it. Yet this metal is considered to be the nightmare in many mining operations, and it is not worth very much because at the present time it only has a few applications. Developing nuclear reactors to generate electricity has been based on uranium, a choice that made it possible to produce plutonium for nuclear weapons. When the uranium-plutonium option was selected, the other alternative, the thorium option, was abandoned. This fuel does not generate waste with weapon potential as a by-product[144]. The US Government constructed an experimental molten salt reactor (MSR) at the Oak Ridge Laboratory using uranium-233 as the fuel, created by bombarding thorium-232 (the only natural isotope) with neutrons. It was in operation for 15,000 hours from 1965 until 1969[145]. Thorium is much less dangerous than uranium, and a new generation of chemists, physicists and nuclear engineers estimate that the thorium path is the key to a new, clean and safe source of nuclear energy[146]. The drawback is the greater cost and the fact that it needs a standard fuel, uranium

141 EURARE, Note 128.

142 KEITH-ROACH, M. *et al*., «Environmental Legislation and Best Practice in the Emerging European Rare Earth Element Industry», in: «Rare Earths Industry, Technological, Economic and Environmental Implications» (Lima, B. & Filho, L., Eds.), Elsevier, pages 279-291, 2016.

143 See Note 93.

144 VERONESE, Note 107, pages 180-181.

145 A detailed review of the subject, with the current situation, strengths and weaknesses at: https://en.wikipedia.org/wiki/Thorium-based_nuclear_power Consultation date 25/01/2021.

146 VERONESE, Note 107, page 178.

or plutonium, to start its chain reaction. Apart from that, nuclear reactors based on thorium-232 are more efficient and the technology is known. It stands out because of its simplicity. It does not need large containment domes or many security mechanisms. It could be used as the destination for the thorium surplus found in rare earth mining[147]. There are three times as many thorium land reserves as there are uranium reserves and they contain more energy than all other fossil fuels together. Monazite is the main commercial source of thorium. It is found in large deposits in India, South Africa, Brazil, Australia and Malaysia. It contains an average of 2.5% of thorium, although in some deposits the percentage is as high as 20%. With technological development in progress, thorium would pave the way for easy-shutdown reactors and would not generate long-life waste, i.e., the radioactivity will have dissipated in half a millennium. Despite all of the above, there are those who consider it to be a costly diversion. According to Nils Bohmer, nuclear physicist and member of the Norwegian ecologist group Bellona: «The advantages of thorium are purely theoretical. The technology development is decades in the future. Instead, I think we should focus on developing renewable technology - for example offshore wind technology - which I think has a huge potential to develop»[148]. At present, of the modern molten salt reactor options, it is liquid fluoride thorium reactor (LFTR) projects that are being researched and developed in fifteen countries, including the EU. In 2020, China was the only country that was actually constructing reactors of this type, two of them currently being built in the Gobi Desert, scheduled to come into service in 2030. The country has chosen this type of reactor as an essential part of its medium- and long-term energy strategy[149], to which aim China originally employed 750 scientists and engineers, a further 400 being later assigned[150].

Return to mining and industry

In 1976, the Government of the People´s Republic of China first blazed the trail (Table 4) towards technological independence,

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147 VERONESE, Note 107, page 179.

148 HARRABIN, R., «Thorium backed as 'future fuel'» BBC (31st October 2013). https://www.bbc.com/news/science-environment-24638816 Consultation date 18/02/2021.

149 TENNENBAUM, J., «Molten Salt Reactors (MSR) and Travelling Wave Reactors», 2020. https://msiainforma.org/es/espanol-reactores-de-sal-fundida-msr-y-de-onda-progresiva/ Consultation date 25/01/2021.

150 VERONESE, Note 107, page 182.

an aspiration it hopes to achieve by 2025, as the world leader in energy and digital transition. Rare earth elements are its main tool, which it is using to research into new properties, to register patents, to exploit applications and to take part in other countries' mining operations. This is not the first time that human ambitions on our planet have moved in that direction. On 13 June 1944 Theodore Roosevelt and Winston Churchill signed a collaboration pact between the two countries «to obtain the mechanisms needed to control many of the world's mineral deposits of uranium and thorium during and after the War»[151]. The aim was that «in the event of an arms race commencing when the conflict ended, the US would be able to rely on sufficient raw materials to guarantee its supremacy»[152]. A few centuries earlier, Daniel Defoe had written[153] how English State intervention should take place to make the textile industry the driving force in economic development. In summary, national manufacturers ought to be protected by imposing taxes on imports, while at the same time charging high taxes on raw wool exports, and applying a Government sponsored industrial espionage policy over Dutch industry, while he also advised that artisans skilled in wool textile production should be brought into the country from the Netherlands. Depending entirely on others and defend this is what seemed to be a suicidal policy until recently, but now it has become the most natural thing in the world[154]. The 2009-2013 crisis in the supply of rare earths and China's domination of the market through prices and exports, instilled panic in users and their governments. In 2020, Chinese domination still provided about half of the world supply[155], controlled by quotas allocated to its six State companies. The impact of the COVID-19 pandemic has highlighted still further consumer dependence not only on renewable energy, but also on other commodities and pre-

151 WATSON, P., «Secret history of the atomic bomb», Editorial Crítica, Barcelona, page 359, 2020.

152 Ibidem.

153 DEFOE, D., «A Plan of the English Commerce», Vernon Art and Science (New Edition 2013), 1728.

154 PITRON, Note 67, page 106.

155 In Spain, rare earth imports stand at 550 tonnes a year for the manufacture of glass and ceramics. Smaller quantities are also imported from Austria, France and Italy. The implications for National Security are very limited and would be associated with a broader context of potential instability affecting the global markets and temporary price rises associated with the so-called «Trade War».
https://www.dsn.gob.es/es/actualidad/sala-prensa/tierras-raras Consultation date 25/01/2021.

pared products supplied by China. The situation though seems to be changing, implementing strategies to reduce dependence on Chinese supplies has increased since midway through 2019, with the governments in the USA, Russia, the EU, Australia and Japan intervening directly (Table 5), by giving tax and economic incentives. Supply sources are becoming increasingly diversified. Pitron in his clarifying, unsettling and provocative book examines this in detail: Japan has reached agreements with India to import rare earths and has adopted an aggressive diplomatic attitude with Australia, Kazakhstan and Vietnam; Germany is seeking mining alliances with Mongolia; and South Korean geologists are holding talks with their North Korean neighbours, etc.[156] Roskill's prediction states that «Whilst China retains its dominant position in both rare earth supply and demand, the increase in non-Chinese affiliated mine and refined rare earth production is a key trend, required not only to meet increasing global demand, but to fulfil the changing requirements of downstream consumers with regards to security of supply and ESG regulation»[157].

The main problems faced by countries nowadays are twofold. On the one hand, there has been an abandonment of mining and a loss of experts that have migrated to China, where there has been a constant increase in the number of rare earth specialists. One only has to review the scientific publications. A conference on rare earths attracts five hundred Chinese scientists, whereas in North America only one hundred attend. On the other hand, as Abraham points out in his interesting book[158] «The average age of the mining workforce in the United States is close to fifty; most will retire in the next ten or fifteen years. Likewise in Canada industry sources estimate that nearly 60,000 workers may retire by 2020, but the sector may need 100,000 new workers to meet demand».

Europe and America require specialists, scientists, technologists and entrepreneurs to exploit their own resources of critical elements and materials, while at the same time patenting applications and manufacturing high tech devices. The bottleneck is neither economic nor geological, but human, and it will take years to train good engineers and metallurgists. Abraham regretfully admits that very few people study rare earths. Only one North American university offered that speciality in 2015, and

[156] PITRON, Note 67, page 199.
[157] ROSKILL, Note 130.
[158] ABRAHAM, Note 31, p. 85.

the 25,000 employees working in that industry in 1970 fell to 1,500 in 2010[159]. It is to be hoped that this serious decline will slow down with the recent upsurge in mining on Western soil, but experience indicates that it takes about fifteen years for a rare earth mine to become fully operational.

Finally, there is the vital role of industry and trading, where the multinationals also play their part. They may act in their own interests, which do not necessarily have to be the same as the national interests. During the crisis with China, Japanese companies acted in their own best interests, which did not coincide with Japan's interest[160]. On a world scale, there was a steady departure of foreign companies to China, which offered them low-cost access and unlimited resources. There, its secret technology was at risk and their specialists formed part of an exodus from their home countries. Globalisation arrived to affect this complex circle of interests. As far as the major international companies with interests in China are concerned, a dualism, a conflict of interests emerges that manifests itself in the political decisions, either in defence of the nation or in defence of the firms that are based in the country. That could largely explain the current situation in North American society. What happens with rare earths is merely just another symptom of this dualism and now the global supply chain is feeling the effects. In his book, Pitron gives an account of the scandal, known as «Chinagate»[161], in which several dozen people were convicted. The scandal revolved around Chinese economic support for Clinton's re-election in the 1996 Elections. Before that, the US Administration had shared with China, the industrial secrets of its missile technology, having been forced to do so by Clinton himself. It would appear that the response to the 2009-2013 crisis, not only regarding those metals but also the energy transition, aims more to a self-defence, far away from the strict concept of globalisation. In another sense, during the opening session (25/1/2021) of the Davos Forum, the President of China said: «Now [in China] we will play a more active role to encourage a world economic globalisation that is more open, inclusive, balanced and to the benefit of all»[162]. For the time

[159] Ibidem, p. 195.

[160] Ibidem, p. 205.

[161] PITRON, Note 67, page 175-176.

[162] DE LA CAL, L., Xi Jinping inaugura Davos pidiendo multilateralismo: «el mundo no volverá a ser lo que fue en el pasado», 2021. Suggestive article in the Macroeconomy section of El Mundo. https://www.elmundo.es/economia/macroeconomia/2021/01/25/600edf7d21efa091338b45a0.html Consultation date 27.01.2021

being, the short-term prediction for rare earths, as quoted by Roskill[163], after the interruptions to industrial production caused by COVID19, there expects to be a sharp recovery in demand in 2021, increasing by 10% year-on-year and backed by a Green Agenda; this is also the target set by many national governments and international bodies that are seeking to reduce carbon emissions.

In the medium term, it must not be forgotten that although China's growth rate is faster than that of its competitors, the country consumes huge amounts of energy. China is boosting the production of its own energy, while at the same time searching for mining resources abroad, including rare earths, estimating that its own production will not be sufficient for domestic consumption. The problem is explained by Kalantzakos[164]: «Although, democratic governments in responding to China's handling of the rare earths crisis achieved a certain level of cooperation (mainly scientific and diplomatic), they did not formulate or enact a central strategic plan that would over time provide a viable alternative to China's dominant position in the industry».

If one reads through the history of protectionist policy of the English Prime Minister Robert Walpole, concurrent with Disraeli, and followed by Roosevelt's new world order, one gets the impression that just like the US Empire and the British Empire before it, a new Empire is beginning to take shape on the horizon, the Chinese Empire, and rare earths bear witness to this.

[163] ROSKILL, nota 130.

[164] KALANTZAKOS, S., «China and the Geopolitics of Rare Earths». Oxford University Press, New York, page 167, 2018.

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