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Thesis' Title	**The Challenge of Renewable Energy Sources as a "Leader" to the New Energy Order.**
Name	**Bitsa Dimitra**
Father's name	**Filippos**
ID	**Men18040**
Supervisor	**Bossis Mary**

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Introduction

In the 21th century the international community is facing a wide range of challenges. The new geopolitics of renewable sources and rare earth elements arise as the main components of the new international energy puzzle. In this new context, the concept of energy security is coming once more to the forefront giving prominence to the diversity of resources and the elimination of supply risk. Does the international community walk towards a new vicious circle?

For a century the fossil fuels have been the leaders of energy sector. The ascendency of the oil as the dominant fuel since World War II and then has defined the developments at many levels such as economic, technological, political and environmental. The stepwise transformation of oil and of energy in general, from a commodity to an economic and political advantage has defined the international relations after the two-oil crisis in the decade of 1970s, accenting the importance of energy as a dimension of national security.

In addition, the gradual awareness on environmental issues and the necessity to protect the environment from the industrialized modus vivendi of humanity in order to reduce the levels of carbon dioxide emissions into the atmosphere, have put the issue of renewable energy at the center of the discussion. However, it took almost two decades for the renewable energy promotion process to intensify. The decreasing construction cost; the general technological advances; the annual UN-level Conferences on protecting the environment; the promotion of sustainable development as a new way of life; and the overall change of public opinion have formed a solid ground to initiate the expansion of renewables.

At first glance, the energy transition could simply be the replacement of one form of energy with another. Nonetheless, investigating the essence of energy transition is revealed that is a radical change, redefining the geopolitics and the global energy economy.

The main purpose of this thesis is to analyze the energy transition that is taking place, in which renewable energy sources, energy efficiency and electrification had the leading roles. These three variables can be analyzed separately, but also, as a threefold function.

The energy transition of renewables promotes the gradual release from fossil fuels dependency. This radical change in the way energy is produced and consumed reappraises the relationship between the human and the environment to a more sustainable one. At the same time, it is emphasized that sustainable and innovative growth will not be destructive for the environment, thus achieving a viable conflation between the two.

Howbeit, the expansion of renewables has increased the demand for rare earth elements, which thanks of their unique properties are indispensable in the construction of the renewables facilities. This evolution, in its turn, creates new challenges for the international community by redefining the geopolitics of energy and underlying, once more, the dependency of human civilization on the natural resources. Hence, the greatest bet for the humankind nowadays is to accomplish the sustainable exploitation of natural resources, in regard of non-exhaustion and preservation of intergenerational right on them.

The politicization of natural resources is not a new political practice of states. The international incidents of the last two decades have confirmed similar practices on the issues of rare earths. In this under transition international energy system, the resources balances are rising in the forefront of the political chessboard, again.

A systematic study of international bibliography was conducted to carry out this research. Particular attention was paid to the study of reports by international organizations, using their conclusions as key milestones. The resolutions of the European Commission and the World Trade Organizations as well as the texts of international agreements constituted the main sources of the primary bibliographical references used. The detailed and multi-dimensional papers by eminent scholars, as well as the articles from reputable online sources have provided an integrated view of the existing knowledge, contributing to further research on the issue under consideration.

The structure of this thesis is organized as follows: the first chapter consists of a brief outline of the historical perspective of energy transition as an eternal process in the history of humanity. Additionally, the importance of energy transition is delineated based on contemporary developments, along with the demand of international community and the new challenges. For the better understanding of the process of energy transition, the states are categorized in five different groups according to their general common characteristics.

In the second chapter a comprehensive analysis of Renewable energy sources is made regarding the stages of their appearance and their gradual expansion and use; the reasons that compel nowadays their widespread use and prevalence in national energy mixes; and finally the geopolitical dimensions of their extensive use.

The third and last chapter is devoted to the analysis of the issue of rare earth elements and specifically to their security and insecurity implications for international community, in an attempt to capture the challenge of renewable energy sources as a leader to the New Energy Order. In the first part, a brief introduction is made to the discovery of the rare earth elements and their importance gradually acquired initially by the academic community and later by the industrial sector. In the second part is studied deeply the geopolitics of rare earth analyzed in four basic dimensions: starting the debate on the question of comparing the fossil fuels and rare earths is highlighted their significance as critical elements, giving the baton to an in-depth analysis of a potential supply risk. The danger of a supply risk arises further discussion for possible solutions to cope with, highlighting the dilemma between the solutions of substitutes or recycling elements, or even a possible combination of both of them. Finally, the analysis of geopolitical dimensions of rare earth is completed with the confrontation of China and all the other players in the international agenda, in an attempt to be outlined the balance of power, the new energy rearrangements and the possible challenges and threats of the next day.

Chapter 1

The New Energy Order.

1.1. Going through the path of Energy Transition.

1.1.1. A brief introduction in the historic perspective of Energy Transition.

The energy transition is not a new phenomenon in the global history. Contrariwise, it is an ongoing process directly related to human nature and the need for constant development. The consecutive use of wood, coal, oil and natural gas, and finally renewable energy, in a way, describes the evolution of both industrial and technological sectors and the humanity in general.

The First Industrial Revolution (1760 - 1840) was the tipping point for the expansion of the use of coal, firstly in the transportation sector (steam engine, steamships, and steam-powered railroads) and gradually in the defense industry as well as the electricity generation. On the eve of World War I, the Winston Churchill's decision[1] to turn the British Navy to the use of oil instead

[1] Yergin, D. (2006) Ensuring Energy Security, Foreign Affairs, Volume 85, No 2, pp. 69-82

of coal signified a major step for the global energy market, bringing to the surface the significance of the concept of energy security. Hereinafter, the Royal Navy was relied on the oil supplies imported from the Persian region and not on Wales' reliable coal. Accordingly, the accomplishment of energy security became a part of national strategy, turning oil into an essential tool of the international economy and politics.

The more the technological innovation was gaining ground in the fields of manufacturing, agriculture, heating, marine and air transports and the global automobile industry was gradually consolidating, the need for oil was becoming sharper. The two oil crisis of 1973 and 1979 shot up the international oil price, at extremely high levels for that time ($30 per barrel)[2], transforming oil security from a military issue into an economic stability one.[3] Consequently, the concept of the "strategic resource" arrived as a bare necessity in the base of dealing with a possible future embargo.[4] Secondly, many states started to search for new energy resources in other areas of the planet, namely in the Alaska or the North Sea, or to invest in new forms of energy. A great example of that period's energy crisis is the case of Brazil, who decided to produce biofuel from sugar beet in an effort to mitigate its oil import dependence.

A complex of several events, starting from the decade of 70s until today, has gradually led to the new Geopolitics of Energy. Notably, the enormous power rivalry over specific oil-abundant parts of the world (Persian Gulf, the Caspian, the Arctic, Strait of Hormuz, Suez Canal), the controversial character of nuclear energy, the gas crises between Russia and transit countries (Ukraine, Belarus) and the liberalization of the energy market (restructuring of electricity, telecommunication and gas grids sectors) have broken up the monopolies and have consolidated the free market and the free economy. Finally, the current rapid growth of renewable energy as an alternative source against the fossil-fuels dependence offers an additional argument to the new conceptualization of the energy transition and the New Energy Order.

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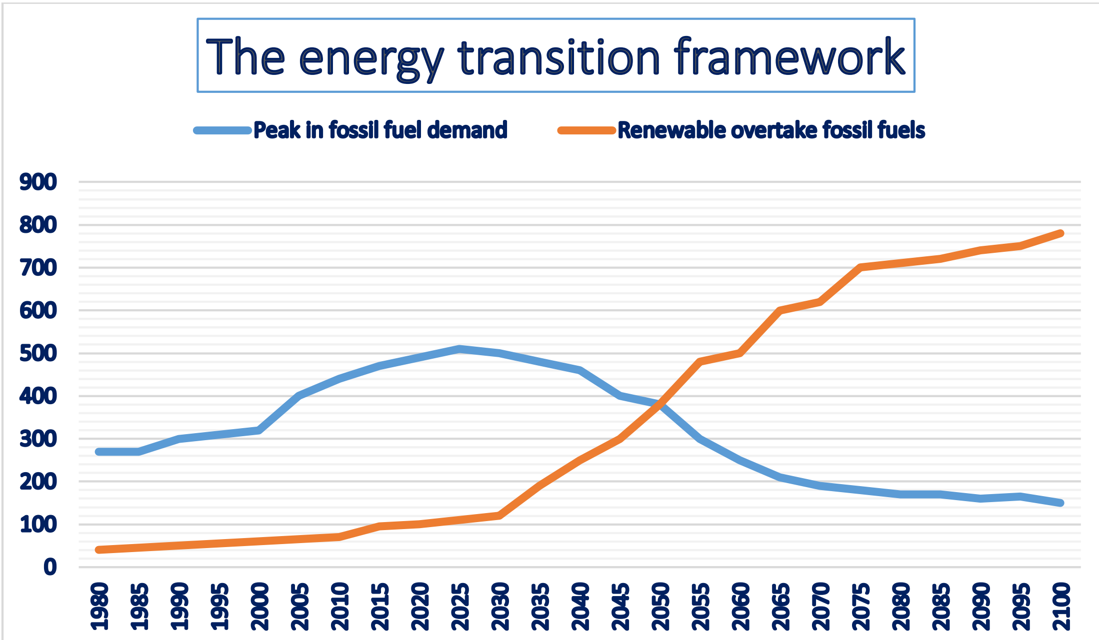
[2] Paravantis, J., Ballis, A., Kontoulis, N., Dourmas, V. (2019) Conceptualizing and measuring Energy Security: Geopolitical Dimensions, Data Availability, Quantitative and Qualitative Methods, in *Machine Learning Paradigms*, Springer Nature, Switzerland AG.

[3] Overland, L. (2019) The geopolitics of renewable energy: Debunking four emerging myths, Energy Research and Social Science 49, pp. 36-40.

[4] Μπόση, Μ. (2018) Οι όψεις της διεθνούς ασφάλειας, Εκδόσεις Ποιότητα, Βάρη Αττικής.

Figure 1.



Source: IRENA, A New World. The Geopolitics of Energy Transition.

1.1.2. Representing the substance of Energy Transition.

The Renewable Energy Sources, the energy efficiency and the electrification are the three basic variables of the new energy transition.[5] The main renewable energy sources are bioenergy, geothermal, hydropower, ocean, solar and wind, with the last two underscore a very rapid growth.[6] The noticeable difference between the renewables and the fossil fuels is the fact that the first one are dependent on flows rather than exhaustible stocks and also can be developed in a widespread location.[7]

Energy efficiency enables economic growth with lower energy inputs, favoring the energy consumption index and readjusting the energy demand index. According to the International Renewable Energy Agency, the primary energy demand is anticipated to grow at 1% a year in the period to 2040, in comparison with the average growth-rate demand of 3% during the twentieth century.[8]

Electricity sector accounts for 19% of total energy consumption, but its share is expected to keep growing, as increased electrification of end-use sectors takes place.[9] The estimated share of renewables in global electricity generation was more than 26% by the end of 2018.[10] Electricity has been the fastest growing segment of final energy demand, achieving two-third faster growth than total energy consumption since 2000.[11] To the contrary, the sector of heating and cooling presents a minor growth because of the lack of a substantial policy. Additionally, in the transport sector, despite the increased use of biofuels (ethanol and biodiesel) in vehicles for 2018, the slow progress in developing renewable fuels for markets such as aviation, contributes to the almost zero growth in the sector.

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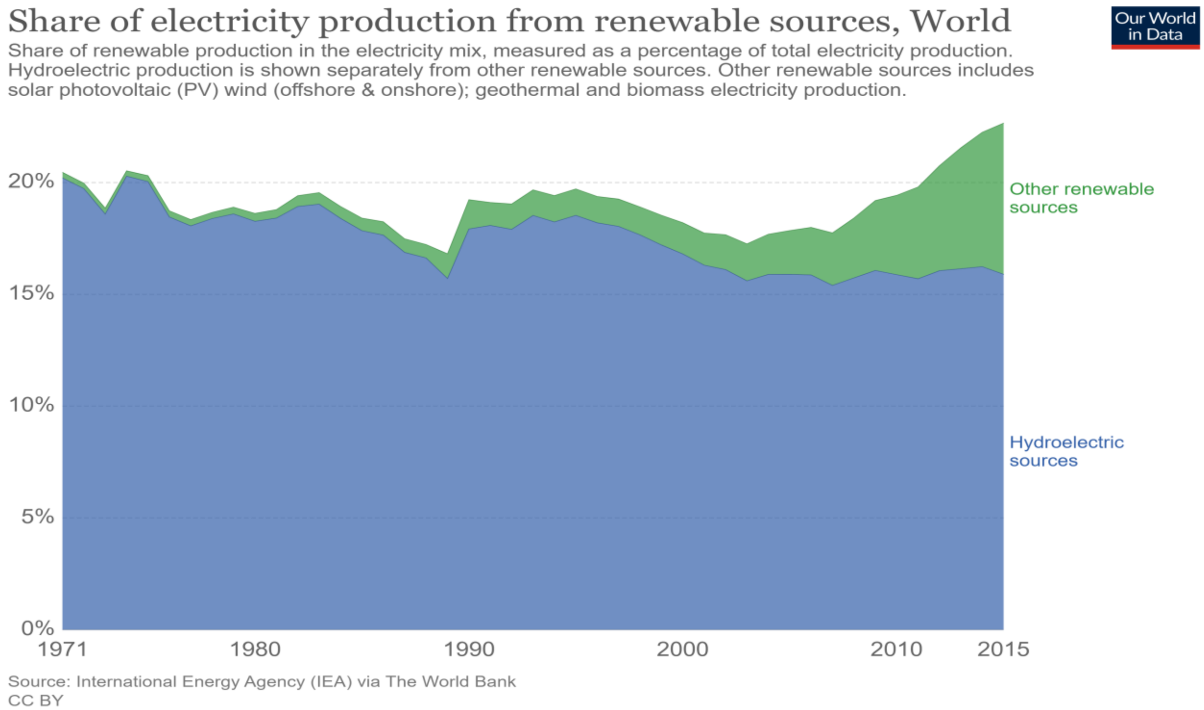
[5] IRENA, OECD/IEA and REN21 (2018) Renewable Energy Policies in a Time of Transition, International Renewable Energy Agency, Global Commission on the Geopolitics of Energy Transformation (2019) A New World. The Geopolitics of the Energy Transformation, International Renewable Energy Agency.
[6] Solar PV capacity 405GW on 2017 to 505GW on 2018. Wind Power capacity 540GW on 2017 to 591GW.
[7] Johansson, B. (2013) Security aspects of future renewable energy systems – A short overview, Energy 61, pp. 598-605.
[8] Global Commission on the Geopolitics of Energy Transformation (2019) A New World. The Geopolitics of the Energy Transformation, International Renewable Energy Agency.
[9] IEA (2018) World Energy Outlook 2018, International Energy Agency.
[10] REN21 (2019) Renewables 2019 Global Status Report, Renewable Energy Policy Network for the 21st Century
[11] Supra note 7

Figure 2.



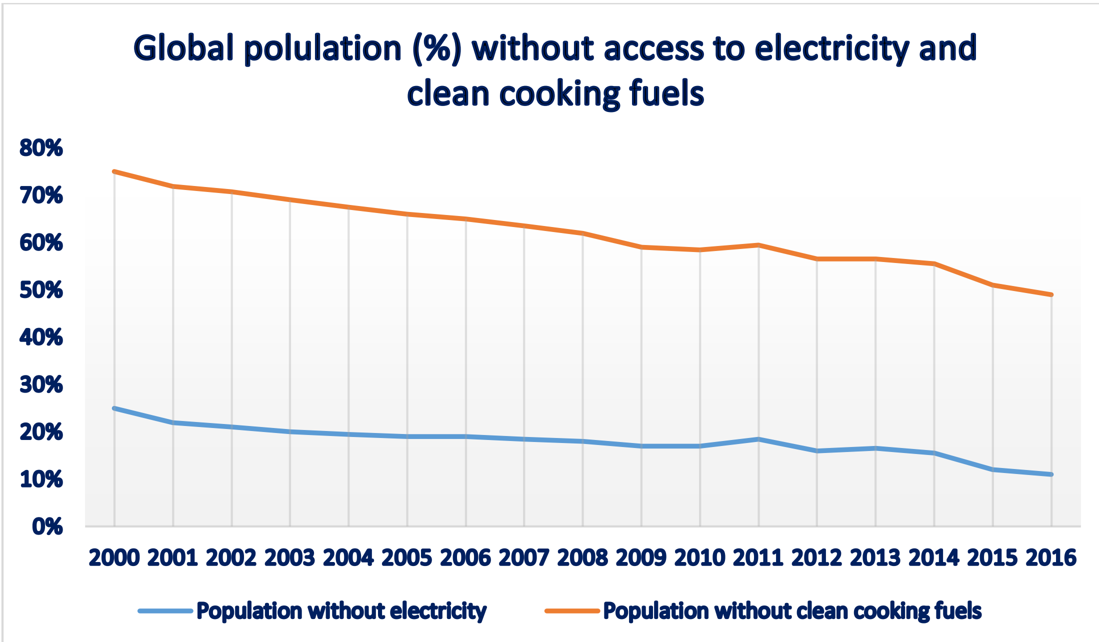
Source: Our World in data. https://ourworldindata.org/renewable-energy

Summarizing, the concept of energy transition, nowadays, is a complicated and multifaceted one. In the past, the energy transition mirrored the consecutives changes in the form of fuels used or the discovery of new sources.[12] Nowadays, it represents a step forward to the reorganization of the energy chains and energy market based on the various forms of traditional and new forms of energy, entailing political, economic, technological, environmental and social implications and dimensions. The new form of the energy market with the participation of many different players in all the stages of the production and distribution of energy imposes the need for a new regulation to deal with the new situation that is coming up. The new advanced technology and the investments in energy efficiency and smart grids contribute significantly to economic growth and the creation of new jobs. In parallel, the investments in electrification in developing states through international programs emphasize on the social profile of affordable energy for all.

[12] Bazilian, M., Sovacool, B. and Moss, T. (2017) Rethinking Energy Statecraft: United States foreign policy and the changing geopolitics of energy, Global Policy, Vol.8, Issue 3.

Finally, the role of climate change as a threat multiplier[13] and the need for the promotion and implementation of massive decarbonization policies underline the geopolitical significance of energy in international security balance.

Figure 3



Source: World Bank

[13] Solana, J. (2008) "Climate Change and International Security" paper from the High Representative and the European Commission to the European Council, S1133/08. Available from: https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf (accessed 22/09/2019).

1.1.3. Approaching the Energy Transition per group-country.

The ongoing transition of our times does not only represents the gradual replacement of the traditional fossil fuels to renewables one. It implies an essential transformation of the world's energy systems driven by not only economic criteria, but also social and political factors. Howbeit, energy transition is expected to follow different rhythm from country to country according to the special characteristics of each one of them. The energy system structure, the level of the regulation and political commitment, the volume of invested capital, the human capital and consumer participation, the infrastructure and innovative business environment and institutions and governance are six dimensions composing the Energy Transition Index 2019.[14] By using this Index, we can extract many important arguments on the pace of energy transition worldwide. Additionally, the energy transition in order to be successful should attain energy security and access, environmental sustainability and economic development in balance. The well-known energy triangle.

For the better understanding of this transition, the countries have been categorized into wider geographical areas based on their common characteristics, following the template of 115 countries of the 2019 Insight Report of the World Economic Forum.[15] There are five main categories: Advanced Economies, Emerging and Developing Asia, Sub-Saharan Africa, Latin America and the Caribbean, Middle East and North Africa. This categorization can help all the players (national and local governments, institutions, investors and community) that participate in the energy transition process to realize the correlations between states and energy markets, the advantages and disadvantages of each one and finally promote their cooperation and investment opportunities in a healthy and sustainable environment.

The **Advanced Economies**[16] represent mainly net energy import countries, with the exemptions of Norway, Canada and Australia. The key to their energy security policies has been the diversification of the fuel mix and a wide list of routes and suppliers, aiming in achieving both affordability and sustainability of their internal markets. The first aim concerns the level of retail

[14] Provides scores for 115 countries spanning the many dimensions of energy transition performance and enablers.
[15] World Economic Forum (2019) Fostering Effective Energy Transition, Insight Report, March 2019, Geneva.
[16] USA, Canada, European countries, South Korea, Australia, Japan, Israel, Singapore, New Zealand, Costa Rica, Chile.

electricity prices, highlighting the complexity of keeping energy prices affordable while investing in energy transition. The second one imposes the challenge these countries face in order to reduce the high levels of carbon emissions per capita because of their higher carbon intensity fuel mix and their carbonized technology and economic development.

The **Emerging and Developing Asia**[17] counts nearly the 50% of the world population. The thirteen countries of the group present a significant diversity as far as concerns their income levels, institutional arrangements and economic structure. The common point is their high urbanization rate. The majority of the countries are net energy importers, with a dominant use of coal into their energy mix. China and India, despite having been heavily reliant on fossil fuels imports, they invest significant capital in the renewable sector with the scope to achieve their energy independence and climate goals.[18] Malaysia, to cope with the challenge of carbon emissions, has decided to increase the installed capacity of renewables from 21% to 30% and invest in the new high-cost technology coal plants of higher efficiency and lower emissions.[19]

The **Sub-Saharan Africa**[20] represents the lowest levels of per-capita energy access worldwide. More specifically, roughly, 600 million people lack electricity and thirteen countries of this category have less than 25% electricity access.[21] At the same time, the cost of electricity is extremely high, and many countries rely on inefficient, expensive, small-scale, oil-based power generation.[22] As expected, the lack of energy access decelerate the economic growth and the sustainable development of the region. Specifically, in 2018, the economic growth rate reached just 2.8%. Furthermore, the political instability, the lack of a strong institutional framework, the corruption and the internal political upheaval create a controversial and precarious environment for attracting foreign investments.

The countries of the group are rich in natural resources. Nigeria and Algeria are major oil producers and owners of natural gas. Mozambique and South Africa control a high percentage of

[17] Malaysia, Brunel Darussalam, Thailand, Vietnam, Philippines, Sri Lanka, Indonesia, India, China, Bangladesh, Nepal, Cambodia, Mongolia,

[18] Supra note 7

[19] Supra note 15

[20] Namibia, Kenya, Ghana, Tanzania, Algeria, Senegal, Botswana, Ethiopia, Zambia, Cameroon, Benin, Nigeria, Mozambique, Zimbabwe, South Africa.

[21] OECD, UN Environment, World Bank Group (2019) Financing Climate Future: Rethinking Infrastructure. Achieving clean Energy Access in Sub-Saharan Africa.

[22] Cherp, A., et al (2012) Chapter 5: Energy and Security, on Global Energy Assessment: Toward a Sustainable Future, Cambridge University Press, UK and New York and the International Institute for Applied Systems Analysis, Luxemburg, Austria.

coal exports in Africa. The diversity of energy resources in Africa is relatively low, with the oil representing the dominant fuel in most countries, where coal and natural gas are following. Poverty and extremely weak technological background have hampered diversification into renewables. Due to recent discoveries of oil and gas, and abundant coal in Botswana and South Africa, the share of renewable energy in the power generation mix declined in 2018.[23] Additionally, Sub-Saharan Africa has enormous potential in renewables including hydro, solar and wind.

The key for the reconstruction of this region is the exploitation of the renewables on their energy mix in order to come up with the energy poverty, to promote a stable and sustainable development, to cut off the dependence between economic growth and oil rents (Nigeria) and gradually ameliorate the economic growth rate. The radical transform of the energy and economic system will improve the human health and well-being conditions by creating new jobs and by boosting the human and energy security.

At this time, there is a significant number of energy projects under construction in the region of Africa, under the form of financial aid, aiming in the creation of an affordable, reliable and sustainable energy system. Accordingly, the World Bank (WB) had been one of the major contributors for the period from 2014 to 2018, who has already provided more than $11.5 billion in financing renewable energy and energy efficiency.[24] To name some of them: *Nigeria Electrification Project* (Nigeria); *first utility scale solar power plant*, supported financially by the International Financial Corporation (IFC) and Climate Investment Fund (Mozambique); f*irst utility-scale wind farm* supported also by the Multilateral Insurance Guarantee Agency (MIGA) (Senegal); *Scaling Solar Program*, WB, IFC and MIGA (Zambia). The Power Africa project,[25] supported by the U.S Agency for International Development, aimed at the enablement the electricity access by adding 60 million new electricity connections and 30,000 MW of new cleaner power generation. This project brought together a number of experts, technical and legal, the private sector and governments from around the world to work in cooperation in order to eliminate energy poverty and help countries to achieve the energy triangle of security, access and affordability, environmental sustainability and economic development and growth.

[23] Supra note 15
[24] World Bank (2019) This is what it's all about: Boosting Renewable Energy in Africa (online). Available from: https://www.worldbank.org/en/news/feature/2019/02/26/this-is-what-its-all-about-boosting-renewable-energy-in-africa (Accessed 20/09/2019).
[25] USAID (2019) Power Africa (online). Available from: https://www.usaid.gov/powerafrica (accessed 20/09/2019)

Table 1. Energy projects under construction in the region Africa.

Nigeria	Nigeria Electrification Project	World Bank
Mozambique	First utility scale solar power plant	IFC & Climate Investment Fund
Senegal	First-utility scale wing farm	MIGA
Zambia	Scaling Solar Programme	WB, IFC, MIGA
	Power Africa Project	U.S. Agency for International Development

The **Latin America and the Caribbean**[26] present a great disparity in per-capita energy demand, which is affected by the level of income and energy access. This group of countries is an excellent example of great renewable use, recording the highest share of renewables and second-lowest share of oil, gas and coal within its energy mix compared to other country groups, and especially the Advanced Economies group; 8% renewables share in 2016 in comparison to almost 2% share in the energy mix of Advanced economies.

Hydropower comprises the primary renewable source of electricity for many of the region's countries. However, the climate change with the increased droughts and the occasional limited rainfall threat significantly the secure and uninterrupted electricity supply. For instance, Brazil since 2013 had being experienced decreased water levels, peaked in 2015-2016, causing the worst water shortage in the last 35 years. As hydroelectric output fell during this period, generation from other fuels such as natural gas and liquid fuels increased.[27] The fear of prolonged droughts, astoundingly, can lead to increased use of non-renewable power plants, resulting in increased carbon emissions. Furthermore, many of the hydropower generating facilities are located far from the main centers, which results in high transmission and distribution losses.

The biggest challenge for this group is to cope with the negative impact of climate change attaining environmental sustainability. Incidentally, the construction of regional electrical networks will deepen the integration of energy systems, offering increase competition and lower energy prices within the region, and finally, improving the security of supply and resilience of the grid system.[28]

[26] Ecuador, Paraguay, Argentina, Guatemala, El Salvador, Dominican Republic, Trinidad and Tobago, Bolivia, Nicaragua, Venezuela, Haiti.
[27] EIA (2019) Brazil (online), Available from: https://www.eia.gov/beta/international/analysis.php?iso=BRA (accessed 21/09/2019)
[28] Supra note 15

The **Middle East and North Africa**[29] countries record the biggest percentage of fossil fuel in their primary energy supply reaching a significant percentage of 92%.[30] The special geopolitical conditions of this region restrict the prospect of an energy partnership or even the possibility of new investments. In general, all the countries of this group record high levels of carbon emissions as a result of loose regulation in environmental protection and sustainability.

The fossil fuels abundance guarantees the lowest average household and industry electricity prices and the lowest wholesale gas prices. Furthermore, the level of electrification is extremely high reaching an average of 98%. Nonetheless, the concentration of oil and gas within their energy mix impose a serious breach in their energy security.

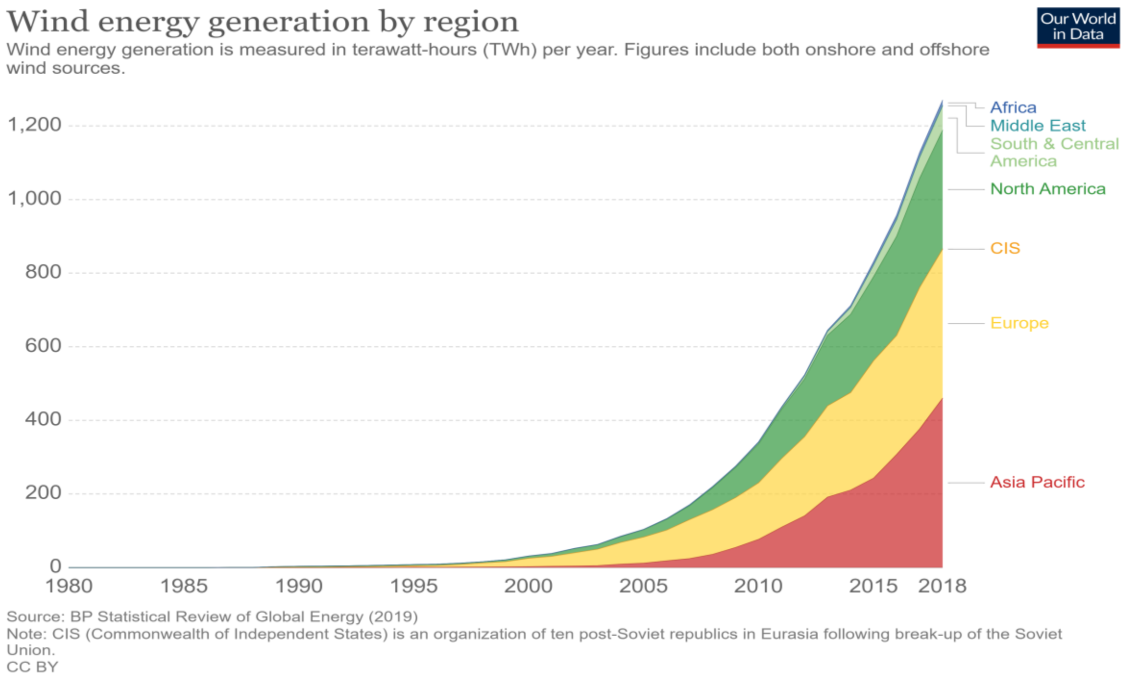
Therefore, the big bet for this group is the gradual release from the exclusive use of traditional fossil fuels. A smooth transition to the new energy order should begin from the diversification of their energy mix in order to achieve energy security, environmental sustainability and an economic growth released from oil rents. From this perspective, the last two years Saudi Arabia and United Arab Emirates have been examining and promoting projects to increase the use of renewables in the power sector displacing oil consumption significantly: Saudi Arabia to have over 60GW of installed capacity by 2030 and United Arab Emirates to reach 44% from renewables in its energy mix.

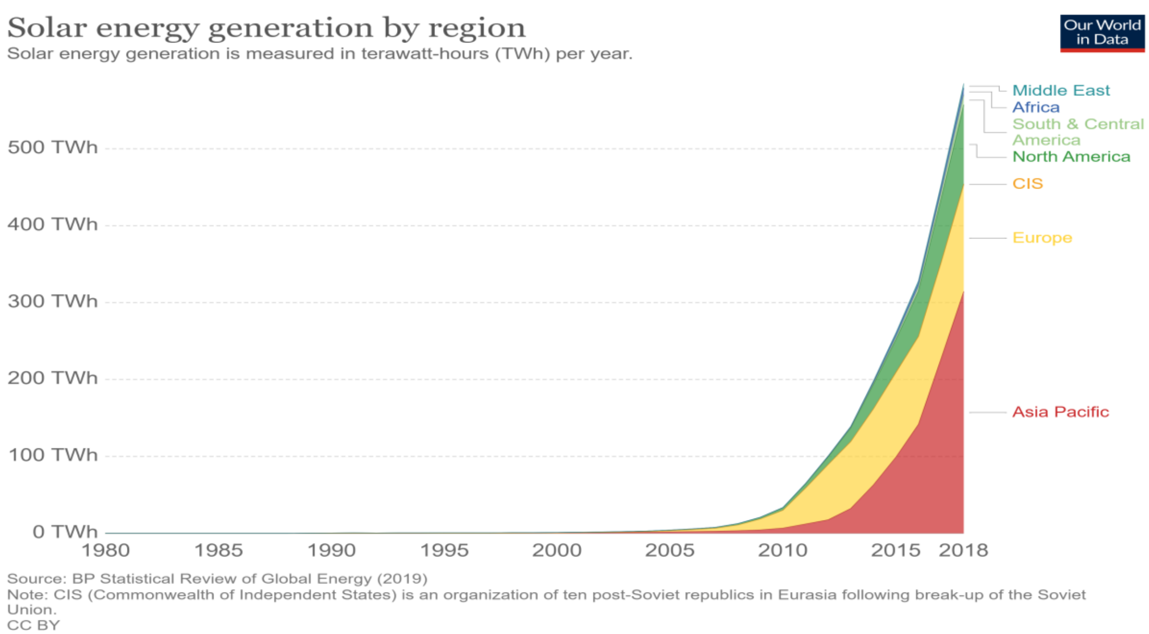
Concluding, from the above analysis a number of extremely important inductions have been extracted. First of all, energy transition cannot take place on a one-way process by all states. On the contrary, it is going to be a multilevel process following the special characteristics of each geographical area, and each individual state. The cooperation should be prevailed between states, for the purpose of being actualized properly and with no rivalry or any possible intent of enforced domination by the powerful states to feeble one. The investment in third countries should aim at economic development of both sides and not in the economic exploitation of the financially weaker. The main goal of energy transition should be, at all costs, a moral and technologically equal transformation of our society, a balance between established economic, social and political system.[31] In other words, energy transition could, hopefully, contribute to an ultimate political

[29] Morocco, Qatar, Jordan, United Arab Emirates, Oman, Tunisia, Egypt, Kuwait, Bahrain, Pakistan, Saudi Arabia, Islamic Republic of Iran, Lebanon
[30] Supra note 15.
[31] Supra note 15

change and a reshaping of the political power achieving energy democracy[32] at all levels, within the realm of feasibility.

Figures 4 & 5





Source: Our World in Data. https://ourworldindata.org/renewable-energy

[32] Burke, M.J., Stephens, J.C., (2018) Political power and renewable energy futures: A critical review, Energy Research and Social Science, 35, p.78-93.

1.2. Energy Security: is it possible to reach a general approved definition?

The concept of National security has been for many years directly connected with the defense of a state, echoing a military complexion. Notwithstanding, the important historic facts (economic and social) which succeeded the WW II in combination with the continual expansion of the globalization process have contributed significantly to a more broaden examination and conceptualization of national and international security.

The traditional approach of national security is connected with the concepts of independency, self-determination and dominance of a state. The gradual establishment of the open market had facilitated the free trade and finally had brought the states closer in terms of economic cooperation and interdependency. This new reality along with the intensification of globalization had created the appropriate conditions for the appearance of the concept of international security.

The United Nations Charter in article 1 [33] introduced the purpose of maintaining international peace and security under the implementation of International Law, insisting on the prerequisite to abstain from any act that could threat world peace. The creation of a stable and secure environment would facilitate the cooperation and trade among states. In such a peaceful environment, every state could draw its national policies aiming at stable economic growth, technological development and self –sufficiency on appropriate resources that would enable the peaceful coexistence among states. Nevertheless, within the Realism, the anarchic System itself

[33] Charter of the United Nations:
Article 1: The Purposes of the United Nations are:

1. To maintain international peace and security, and to that end: to take effective collective measures for the prevention and removal of threats to the peace, and for the suppression of acts of aggression or other breaches of the peace, and to bring about by peaceful means, and in conformity with the principles of justice and international law, adjustment or settlement of international disputes or situations which might lead to a breach of the peace;
2. To develop friendly relations among nations based on respect for the principle of equal rights and self-determination of peoples, and to take other appropriate measures to strengthen universal peace;
3. To achieve international co-operation in solving international problems of an economic, social, cultural, or humanitarian character, and in promoting and encouraging respect for human rights and for fundamental freedoms for all without distinction as to race, sex, language, or religion; and
4. To be a center for harmonizing the actions of nations in the attainment of these common ends.

Available from: https://www.un.org/en/sections/un-charter/chapter-i/index.html.

creates a rivalry between states pushing each one of them to pursue to reign over the others, either by military and economic means (hard power) or cultural ones (soft power), in order to fulfill their national goals. All this confrontation has characterized the International System,[34] which has been transformed from a bipolar system after WWII into a monopole after the collapse of the Soviet Union. Yet in the new century, the multipolar system seems to gain ground again.[35]

The end of the WW II is a benchmark for many reasons. Primarily, it defined the balance among states and alliances. It established the free market and free economy setting the pace to other fields –industry, agriculture, trade, transports, energy and technological innovation- to rise. Gradually, all the above-mentioned fields of economic activity have been incorporated to the concept of security, which is under a constant evolution.[36] Furthermore, the threats for security can be identified in five basic fields: military, political, social, economic and environmental. During that period, the changes in the domain of energy were very decisive in the way they have affected those five fields.

For many years, the dominance of oil and its products as the main fuels in the transportation sector or in the culinary and heating activities has created its direct connection to energy security. The energy has been transformed from a commodity to a factor of national security defining the policies and challenges. The absence of a general accepted concept on energy security indicates that each category of states participating in the energy chain (producers – consumers – transit states) appreciate it in different ways. A tipping point for all states is, unarguably, the need for seamless access to energy sources. The International Energy Agency has defined energy security as *"the uninterrupted availability of energy sources at an affordable price"*.[37] This concept is indicative to the purpose of the establishment of the organization in the decade of 70s.

In the bibliography, there is a significant number of attempts to interpret the energy security definition. According to Bengt Johansson,[38] in the concept of energy security can be seen two dimensions, the objective and the subjective one. In the first dimension, energy is being anticipated as an object exposed to security threats, measuring the security of supply and the security of

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[34] Supra note 4
[35] De Ridder, M., (2011) The Geopolitics of Mineral Resources for Renewable Energy Technologies, The Hague Centre for Strategic Studies.
[36] Supra note 4
[37] IEA, What is energy security? Available from: https://www.iea.org/topics/energysecurity/whatisenergysecurity/, (accessed 10/09/2019).
[38] Johansson, B. (2013) A broadened typology on energy and security, Energy 53, p. 199-205.

demand. In the second definition, the energy system itself is considered as a subject that generates insecurity or behaves like a threat multiplier, in combination with economic and political and also technological and environmental risk factors.

It could be argued, that the first definition represents the traditional approach of energy security in the terms of dominating oil use. The second one entails all the components of the contemporary complex international energy system, underlining that the concept of energy security cannot be constrained, just, in the terms of supply and demand. To the contrary, all the fields[39] that compose the national and international security should be taken into consideration, highlighting the complexity and the interaction of the international system itself.

Cherp and Jewell allege that *energy security challenges began first and foremost as separate policy problems.*[40] They initiated their research starting of the historic and geopolitical perspectives of energy security; they continued with the identification of the role of technical systems in natural resources in the prospect of energy security; and they ended up including the economic dimension of the role of markets and possible unexpected crisis. As a result, three distinct perspectives on energy security emerged: sovereignty[41], robustness[42] and resilience.[43] These perspectives insist on economic and political, technological and military dimensions of energy security, excluding the social and environmental ones.

Ren and Sovacool,[44] suggest their own quantifying assessment on energy security, based on four dimensions, known as the four As: availability[45], affordability[46], acceptability[47] and

[39] As have been mentioned above, the five fields that entails threats for the security are political, economic, social, environment and military.
[40] Cherp, A. and Jewell, J. (2011) The Three Perspectives on Energy Security: Intellectual History, Disciplinary Rootsand the Potential for Integration. Current Opinion in Environmental Sustainability, 3:4, p. 202-212.
[41] Sovereignty: focuses on disruption potentially arising from actions of external actors, and impose a protection mechanism (military, political, economic or technical means) increasing control over energy systems. A sovereign state is the goal for energy independence.
[42] Robustness: focuses on risks that arise from predictable and largely controlled characteristics of energy systems. Scarcity of energy resources, failures of infrastructure or inadequate capacity to cope with the rising demand. Main strategies should be shifting to more abundant and accessible energy sources, investment to infrastructure, ameliorating energy intensity to achieve more affordable prices.
[43] Resilience: emphasizes unpredictable factors affecting energy security, focusing on diversity of energy options as the main strategy to cope with the potential threats.
[44] Ren, J. and Sovacool, B. (2014) Quantifying, measuring, and strategizing energy security: Determining the most meaningful dimensions and metrics. Energy 76, p. 838-849.
[45] Availability relates to the physical or geological existence of energy resources and the ability for a given community or country to secure those resources.
[46] Affordability includes economic considerations such as price, equity, and price stability.
[47] Acceptability refers to social and environmental concerns associated with energy production and use.

accessibility[48] and twenty four metrics that contribute to the identification of each dimension. For the calculation of the dimension are used both quantifying and qualified metrics. The results are more accurate since there are available and credible data. According to the researchers, each dimension is necessary for the achievement of energy security. Any absence of one of them equates to a breach on energy security of the state.

The term energy security has evolved through the years. After the two economic crises in 1973 and 1979, and the following years, energy security was synonymous to the access to a stable supply of cheap oil. After the 2000s, the priorities have been changed, insisting on affordable and clean energy[49] for all the people in order to cope with the negative impacts of climate change.[50]

The absence of a generally accepted concept on energy security underlines the controversy of this issue. As it is mentioned in the previous chapter, the process of energy transition takes place at a different pace in each state and in each geographical area. The level of technological development and economic growth, the political priorities and the level of living conditions of each state compose an individual approach of what "security" means for each state. The categorization of states into geographical areas help the researchers to extract significant conclusions in order to draw up basic coordinates on energy security, which on the one hand enable comparisons and on the other hand contribute to addressing any energy security weakness.

The history of energy transition shows that states invest in the field of energy aiming at achieving security and general prosperity. A fact that is justified, also by professor Mary Bossis stating, "security in energy constitutes the most important dimension in state's active policy".[51]

The studies of energy security that have been mentioned above, offers to the bibliography a good base to make assumptions and conclude to significant ascertainments. The new ongoing energy transition is concentrated in the triptych: renewables – efficiency – electrification. The investments in these three fields all over the world offer a suitable ground to examine the challenges for energy security. The transition to new forms of energy aiming at security, at the same time could lead to unexpected conditions of insecurity, because of the collapse of the

[48] Accessibility relates to geopolitical elements and the robustness or resilience of the entire system.
[49] Goals 7 and 13 of United Nations Sustainable Development Goals, Available from: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed: 30/09/2019).
[50] Proskuryakova, I. (2018) Updating energy security and environmental policy: Energy security theories revisited, Journal of Environmental Management 223, p. 203-214.
[51] Supra note 4

established balances. The security dilemma arises again, influencing states' decision making process and defining, ultimately, the energy market.

A success transition should be organized under a suitable adjustment period that would facilitate the integration of all the states into the system. In a different occasion, any secession could lead to unexpected crisis and conflicts, or even worse, to the collapse of the system.[52] On the other side, the new era of energy transition may provoke new challenges and threats for the international system, launching a new debate on the security and insecurity dilemma. Indeed, the conflict on the exploitation of rare earth elements[53] has already underlined a serious cause for geopolitical and security concerns.

[52] Supra note 1

[53] It is analyzed in the Chapter 3.

Chapter 2

Renewable Energy Sources.

2.1. The faint appearance and the plodding steps in the field of Renewable Sources.

The exploitation of renewable resources for energy production is not a new practice in the history of states. The Dutch Windmills[54] started to be operated towards the end of the sixteenth century for multiple uses. The most important benefits above all were the land reclamation and the management of the problem of sea level,[55] while, on 1850s, windmill became a popular water pumping tool of western homesteaders and railroad builders. In the meanwhile, the use of coal had begun to consolidate in England, in United States and in other European countries, leading the Industrial Revolution.

[54] ProCon (2019) Historical Timeline. History of Alternative Energy and Fossil Fuels, (online) Available from: https://alternativeenergy.procon.org/view.timeline.php?timelineID=000015#1800-1899 (accessed 30/09/2019)

[55] The windmill helped in raising the water of the rising streams and canals, maintaining the balance between the water and the land. This infrastructure was very important giving a vital solution to farmers and fishermen to control the water.

In 1821 was drilled the first natural gas well in Fredonia, New York and later in 1859 the first commercial oil well was drilled in Pennsylvania. In contrast to these fruitful discoveries for the energy future, the French inventor Augustin Mouchot expressed his concern on the limited sources of fossil fuels and especially of the coal in 1860. According to his view, sun's heat could displace the burning of coal. His research into mirror technology led him to invest the first solar energy system,[56] known as "sun meter."

In the early 1870s, oil exploration in Pennsylvania region grew significantly, giving the pace of exploration to other states during the next decade. To this effort, the leading role had John Rockefeller, who under his company "Standard Oil Company of Ohio" aimed at gaining the absolute control of the industry by covering each phase of the process from drilling to produce of oil fuel. Thanks to his efforts and developments, petroleum became the primary energy source in the world.

In the following years, the world was bombed by new investments and developments. The first electric plant, built by Thomas Edison in New York in 1882, pointed out the beginning of a completely new era for the humanity. In parallel, a couple of efforts in hydroelectric or windmill electricity generation did not meet the support to win the gradual dominance of oil. The industrial field voted for oil technology and her benefits against to further investments in renewables.

Furthermore, during the 20th century, which is characterized by a series of very important events (the two World Wars, the development of military industry, the developments in emerging transportation and communication technology, the digital revolution and the general technological evolution) the use of oil has become indispensable, leaving no ground for renewables innovation and investments. In addition, the political will of the developed economies to invest significant capitals in oil resources in their countries or in their allies' resources, contributed, catalytically, to make oil the dominant fuel.

The two oil crisis in the 1970s have confronted many countries with their dependence on oil leading to the first reviews on the gradual release of oil and the need for diversity of resources. Just a year before the first oil crisis, in 1972 took place the first United Nations Conference on the Human Environment in Stockholm. For the first time where the environmental protection was introduced as a global issue. The main directives on that Conference were the following: the

[56] Project Solar UK ltd, (2018) The History of Renewable Energy. Where it all began, (online) Available from: https://www.projectsolaruk.com/blog/history-renewable-energy-began/ (accssed:30/09/2019)

rational use of natural resources, in order not to be exhausted; the boost in the use of renewable sources instead of fossil fuels; the environmental protection as a factor of development for all (developed and developing) with respect to human rights. As we understand, the decade of 70s was a time for huge realisations for the humanity that have routed the future events. The first UN Conference highlighted environmental problems by turning it into an international problem.[57] The two crises have underlined the dangers of oil dependency at all levels: internally and peripherally political; market and price equilibrium; as well as general energy insecurity that was capable of triggering other tensions. Consequently, the field of energy seemed to acquire a close connection to both national and economic security.[58]

The following UN Conference in Rio 1992 initiated the concept and the goal of sustainable development in an effort to find a combination among the social and economic development and the prudent use of natural resources, for present and future generations, too. Moreover, the adoption of the first United Nation Framework Convention on Climate Change was the beginning of the awareness and the attempts to decarbonise the economy. Nonetheless, any efforts in renewable energy technology were almost indifferent and accounted for only a small percentage of the energy mix of some states. What was missing was the technological progress and innovation and the economic profit.

The entrance of 2000s is characterized by a great acceleration on the use of renewable sources. Firstly, the incentive was environmental especially, for those states who, after the signing of Kyoto Protocol (1997), wanted to contribute to a friendly energy footprint by adopting the role of leaders in the decarbonisation initiative. Nonetheless, the gradual exploitation of renewables has revealed more reasons for inventing in the specific sectors. Accordingly, the economic driver and the promotion of new technological developments in innovation and storage capacity were the main reasons that led to the stimulation of the labour market and the diversification of the revenue streams.[59]

The social factor has also played its significant role. It is true that in some cases local conflicts around renewables energy installations have delayed the uptake of renewables.[60]

[57] Δούση, Ε. (2014) Η Περιβαλλοντική Διακυβέρνηση σε Κρίση. *Ριο+20: υποσχέσεις με αβέβαιη εφαρμογή*. Παπαζήσης,

[58] Ren21, The First Decade: 2004-2014. 10 years of Renewable Energy Progress.

[59] Ibid.

[60] Peterson, T.R., Stephens, J.C., Wilson, E.J. (2015) Public perception of and engagement with emerging low-carbon energy technologies: a literature review, MRS Energy Sustain, 2.

Nevertheless, it was just an inhibitory argument and not a determinant one. The upward path of energy demand in many developing and emerging economies for access in electricity and the needs of their growing population, finally, showed up the possibility of renewables to provide needed energy services in a sustainable way and at a lower cost.[61]

China has taken the baton from the pioneering renewable European countries[62], becoming the world leader[63] in renewables manufacture and installed capacity. Furthermore, she increased her investments and capital flows to developing and emerging economies across Africa, Asia, Latin America and the Middle East. Finally, she managed to establish her monopoly in the exploitation and production of rare earths elements.

In the following section are analysed the reasons that contributed in the deployment of renewables constituting a substantial part of energy transition.

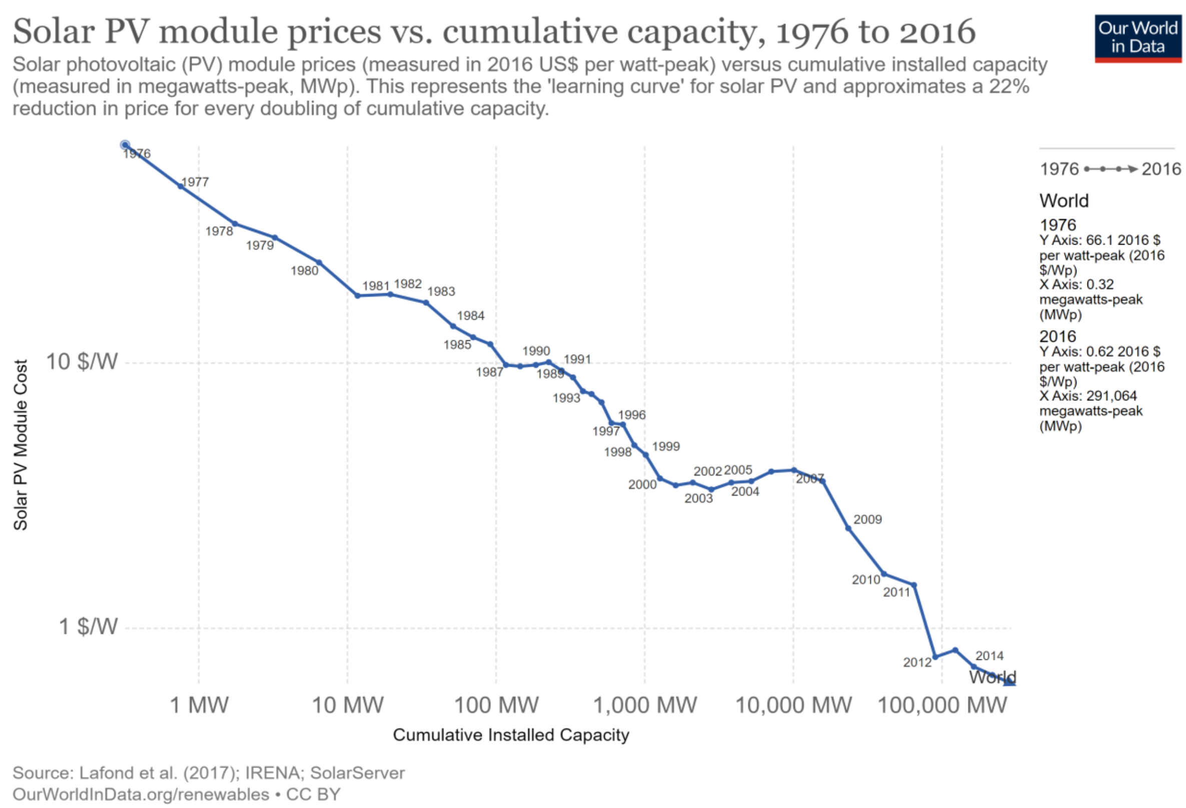
[61] Supra note 57
[62] Germany, Denmark, Sweden, Spain.
[63] Supra note 57.

2.2. The basic arguments that enable nowadays the deployment of renewable energy.

The deployment of renewable energy is a multifunctional result that covers a wide range of factors. Searching in the bibliography, we focus on six major reasons that enable the deployment of renewables.[64]

Primarily, the continuing technological advances, especially in the electricity sector, in combination with their declining costs, as well as, the cheapest solutions in energy storage constructions[65] have boosted the interest for investment. The competitive business models and the profit motive played a decisive role to this investment direction.

Figure 6



Source: Our World in Data. https://ourworldindata.org/renewable-energy

[64] Supra note 7
[65] Supra note 8 and 57

According to the International Renewable Energy Agency's (IRENA) positive estimations by 2025 is expected that the global weighted average cost of electricity is possible to fall by 26% from onshore wind, by 35% from offshore wind, by at least 37% from concentrated solar power (CSP) technologies and by 59% from solar photovoltaics (PV)[66], while the cost of stationary battery storage could fall by up to 60%.[67]

Secondly, the challenge of anticipating with the threat of climate change, air-pollution and environmental degradation have motivated governments, businesses, investors and individuals to recognize the urgent need to decarbonize the global economy. The World Health Organization (WHO) points out that approximately nine out of ten people in the world breathe polluted air that is hazardous to health and well-being and it is alleged to be responsible for the deaths of 7 million people every year.[68] Consequently, decarbonization has positive effects for human security by improving air and water quality and thus public health.

A major step has been made with the signing of Paris Agreement (2015) where 174 countries have committed themselves to strengthen the global response to threat of climate change, in the context of sustainable development and efforts to eradicate poverty.[69] The most challenging goal was the commitment to pursue efforts to limit the temperature increase to 1.5^{O}C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change. Furthermore, reduced greenhouse gas emissions could contribute in mitigating the risk of conflict, instability and insecurity in failed and troubled states because of climate change.[70] Previously, in September 2015 the adoption by the world leaders at the United Nations of the Sustainable Development Goals (SDGs) succeeded a specific energy goal, providing universal access to modern energy services, doubling the rate of improvement in energy efficiency and increasing substantially the share of renewable energy in the global energy mix by 2030. According to the latest Global Status Report 2019, states choose the policy mechanisms of carbon taxes and emissions trading systems to meet climate goals. By the end of 2018, at least 54 carbon-

[66] IRENA, The power to change: solar and wind cost reduction potential to 2025, International Renewable Energy Agency, 2016.
[67] IRENA, Electricity storage and renewables, International Renewable Energy Agency, 2017.
[68] World Health Organization, (2018) How Air Pollution is Destroying Our Health, World Health Organization, Available from: www.who.int/air-pollution/news-and-events/how-air-pollution-is-destroying-our-health. (accessed:14/09/2019).
[69] Article 2 of the Paris Agreement, United Nations 2015
[70] O' Sullivan, M., Overland, I., Sandalow D. (2017) The Geopolitics of Renewable Energy, Columbia SIPA, Harvard Kennedy School, Norwegian Institute of International Affairs, Working Paper June, USA.

pricing initiatives had been implemented (including 27 emissions trading systems and 27 carbon taxes) in comparison to the 46 in the previous year 2017.

Additionally, by 2018, 169 countries adopted a number of renewable targets at the national or state/provincial level.[71] The majority of new targets concerned the power sector, with just a few countries having specific ones for the heating, cooling and transport sectors. For instance, India has adopted ambitious renewables energy targets in an effort to balance its dependence on oil and gas imports. The United Arab Emirates have set the ambitious objective of reaching 44% of renewables in their power supply mix and a 70% reduction in their carbon emissions by 2050. All of this aside, local governments and municipalities, too, are pioneers in pursuing and establishing innovative and ambitious mechanisms. Actually, California has adopted a 60% renewable electricity target by 2030.[72]

In the regional level, EU constitutes a great example of setting goals and taking measures against climate change. In 2007, EU leaders authorized an integrated approach to climate and energy policy that imposed the mitigation of climate change impacts, achieving, simultaneously, both increased energy security and competitiveness. In 2008, the European Commission proposed the adoption of a binding legislation for the implementation of the goals, which finally became active in 2009, under the Renewable Energy Directive 2009/28/EC. The EU, by Energy Policy 20-20-20[73] has set by year 2020 the goal to cover its overall energy needs by Renewables in a proportion of 20%. A key element of this policy, which also reflects the spirit of the European Union, is the cooperation among the states in order to achieve their national and European-common goals.[74] This kind of cooperation is sealed under three support-mechanisms: statistical transfers between member states, joint projects between member states and third countries, and common support schemes. The choice of appropriate mechanism depends on the purpose set and the number of the participants in the agreement, providing an alternative regulatory framework to deal with any difficulties –technical or financial- that member states may face.

[71] Supra note 9
[72] Supra note 7
[73] Energy 2020 — A strategy for competitive, sustainable and secure energy COM(2010)639
[74] Europa, Cooperation Mechanism (online) Available from: https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive/cooperation-mechanisms (Accessed 21/09/2019).

On October 26, 2017, it was signed the first Agreement[75] on Statistical Transfer of Renewable Energy from Lithuania to Luxembourg. For technical reasons Luxembourg could not achieve its national goals on Renewables, as the EU has appointed for it. On the other side Lithuania, by its National Renewable Energy Policy launched in 2010, had achieved its predetermined target already by 2014.[76]

The goal of this mechanism is dual for member states. On the one hand, the prospect of trading their surplus target for substantial financial returns offers them an additional incentive to accomplish their targets. On the other hand, it offers alternative to member states with less efficient renewable energy sources to achieve their objectives at low cost. As it is provided from the abovementioned, the example of EU is a good one for the international community because it stresses the importance of a common regulatory framework and promotes the cooperation among states. The above policy is a part of the new Energy policy of EU aiming at diversity, competitiveness, independency and security of supply.

Maybe, the most decisive argument of the energy transition for the industrial and business sectors is the technological innovation. The higher solar photovoltaic (PV) module efficiencies and taller wind turbines can enable the acceleration of renewables in the electricity sector. In addition, innovations in digitalization and energy storage as well as emerging smart generation and distribution systems ensure the reliable and on-going supply of energy without the fear of no storage-support. Simultaneously, policies and investment projects are concentrated in the expansion and improvement of the existed grid infrastructure so that this can be anticipated with the new energy storage capacities and smart grids. The new energy transition is a bet for the accomplishment of more flexible markets and smarter energy systems in affordable prices.[77]

The energy transition gives prominence to corporations and investor groups to put an extra pressure on companies to reduce their carbon footprint. Specifically, on climate conference in

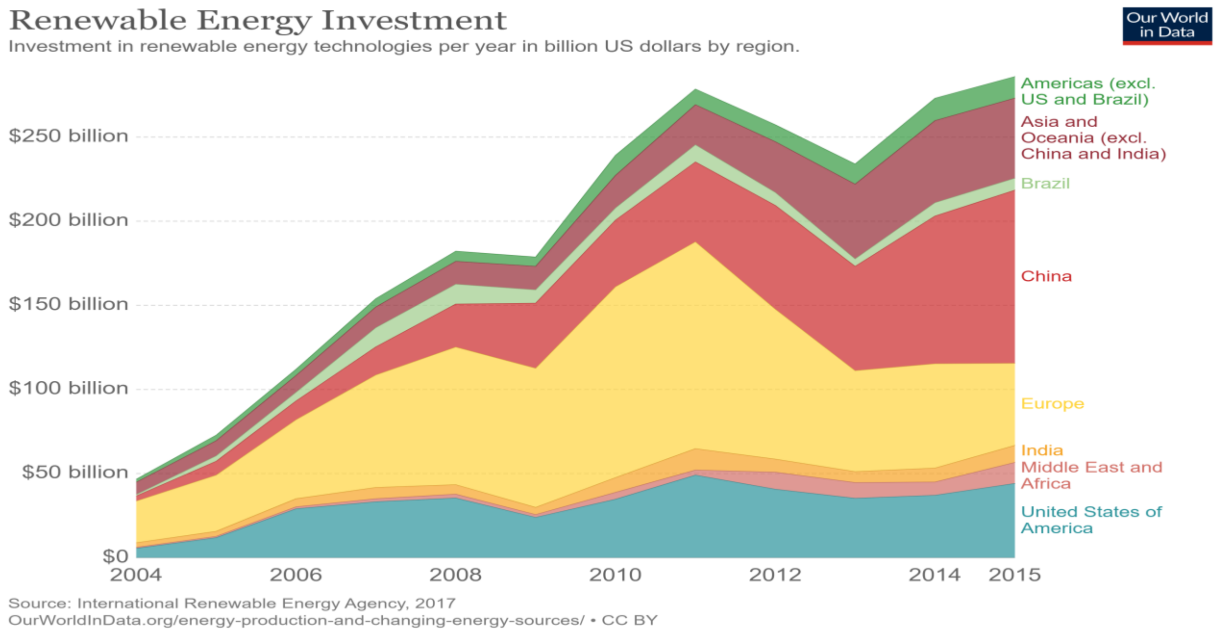
[75] The Cooperation Agreement provides that for the coming years, from 2018 to 2020, Lithuania will transfer its surplus share to Luxembourg, against € 10 million. This revenue will be invested in new renewable energy programs and scientific research in Lithuania.

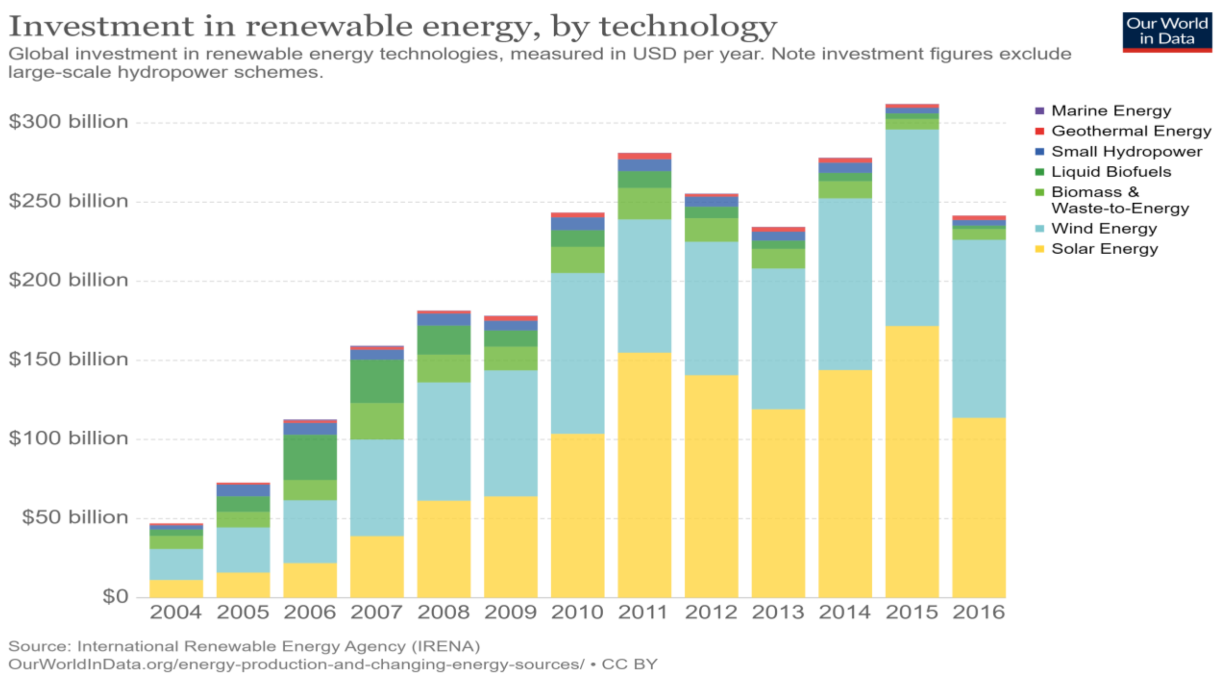
[76] Europa, (2017) Agreement on statistical transfer of renewable energy amounts between Lithuania and Luxembourg (online) Available from: https://ec.europa.eu/info/news/agreement-statistical-transfers-renewable-energy-amounts-between-lithuania-and-luxembourg-2017-oct-26_en (Accessed 21/09/2019).

[77] Supra note 57.

Poland, December 2018, a group of 477 investors reaffirmed their full support[78] to the Paris Agreement expecting from governments to adhere to their commitments.

Figures 7 & 8





Source: Our World in Data. https://ourworldindata.org/renewable-energy

[78] 2018 Global Investor statement to governments on climate change.

Finally, the public opinion is equally important in the battle for extra pressure to governments' decision-policy. From the point of consumers' preferential to environmental-friendly products and demonstrations against air pollution, now we are witnessing a huge global mobilization in favor of climate protection and political change, led by students. In August 2018, Greta Thunberg began protesting outside her school in Stockholm and arguing that climate change was more important than education, for future generations. Within months, a global movement was born by students from all corners of the world. By March 2019, more than 2 million students in 135 countries were striking from school. Consequentially, this motivation by young people, gives an extra argument to Thunberg's slogan *"that no one is too small to make a difference"*. From an international relation theory perspective, the active role of corporation and individuals (with the power to affect and in some to way to contribute to the policymaking) redefine their roles into the international community. More precisely, the role of the state in front of their civilians, and the role of the civilian in relation to the state as well as to the international community.

2.3. The geopolitical implication of renewables in the context of energy transition.

As it is provided from the previous analysis of the two first chapters, the unfolding energy transition represents a "*fundamental raison d'etre.*"[79] The key element of this process is not just the gradual abandonment or restriction in the use of fossil fuels but a different approach in the way we consume and produce energy. The shift to the Renewable Sources can provide the international community with a number of positive impacts in a political- economic- technological- social- environmental level. On the other hand, it can bring states in front of new challenges and geopolitical dynamics.

The diversification of the sources with the orderly shift to the renewables and the gradual drop in fossil fuels consumption draw the new patterns of energy security. The energy independence is becoming an integral part of the energy security. Howbeit, to avoid misunderstandings, to be independent does not mean a complete energy self-sufficiency, but, it rather means the ability to be shielded from possible third- state's actions of energy leverage. Furthermore, state's goal for energy diversification is to provide consumers with a variety of different and affordable choices, and not an act of punishment policy to unreliable energy trade partners.

Anywise, the basic characteristic of the new under formation market is the emergence of the energy flows instead of the exhaustible fossil fuels stocks. Moreover, the fact that renewables can be deployed in one form or another in most countries eradicate the importance of today's strategic energy choke points, contributing to the major, maybe, geopolitical overturn of the 20th century, as it has been formed by the global oil supply after WW II.

That being the case, is being carried out an unprecedented change in the way is calculated and appreciated the "power" of a state. The position of natural resources has been for many years a key element in the geopolitical design of the international system. The energy transition, with a leading role for renewable sources, is anticipated to reassess the geopolitical map in the 21th century under new standards. As it has been analysed in the chapter 1, the distinctive characteristics

[79] Smil, V., (2016) Examining energy transitions: A dozen insights based on performance, Energy Research and Social Science, 22, p. 194-197.

of each state (dependence on fossil fuels, technological know-how, the level of clean energy deployment, investment in innovation) will be determinant in the overall pace of this process, identifying the role of each state on it as leaders or laggards.

As it happens in every energy transition process, new state leaders are risen up. The key characteristics of a state that can ensure a leading role to the contemporary process are: (a) the high technical potential on renewable sources, (b) the possession of mineral resources (rare-earth elements) that will enable the participation of states to the global production and value chains, breaking the Chinese monopoly and (c) the development of a complete and ongoing technological innovation that enables the state to acquire the profits from the global energy transformation. A combination of all the three offers a comparative advantage to any state. The innovation leaders seem to adopt the baton of dominance from the old fossil fuels leaders into the new global energy framework.

However, the most pioneering change in the structure of the energy system is the entry of new actors to the side of the "traditional" states. One of the key characteristic of energy transition is the decentralization[80] and democratization[81] of energy system. Given the fact that people will have the opportunity to install solar panels on their rooftops and produce electricity either for self-consumption or for the central grid, automatically it is created a new category that can participate, actively, in the energy market, this of the prosumers.[82] Consequently, the role of the centralized state may change significantly because of the appearance of new individual actors or business models. In this new, under construction, decentralized energy system, consumers have access to a great variety of energy sources, as well as, a possible share in its economic benefit. However, it is more than necessary the early adoption of a regulatory framework[83] that will precisely define the obligations and the rights of the prosumers, their relationship with the state and with the distribution system operator.

In a general framework, cities are expected to occupy a central role in the energy transformation for a number of reasons. The ongoing urbanization will contribute to increasing energy demand, while citizens will be more exposed to the effects of climate change. A great

[80] Supra note 8.
[81] Supra not 32.
[82] Supra note 8.
[83] Lavrijssen, A. and Parra, A. C., (2017) Radical Prosumer Innovations in the Electricity Sector and the Impact on Prosumer Regulation, MDPI, Sustainability, 9, 1207.

example of the role that cities can adopt is offered by the Covenant of Mayors initiative for local sustainable energy, [84] confirming the dynamic of decentralized system. Consequently, the horizontal dispersion of governmental power entails profound implications for the role of the nation state, inaugurating a new page in the study of international relations.

The new geographies of connections between countries and regions will change from the existed global markets to regional grids, putting electricity in a dominant position. The challenge for states is to invest in smart grids and integrated regional systems in order to be shielded from electricity blackouts and to be able to cope with transportation losses. A great example to this prospect is the European initiative "Baltic Energy Market Interconnection Plan"[85] aiming at the creation of an open and completed regional market of electricity and natural gas in the region of Baltic Sea, creating a recourse bunker against energy insolation. The combination of electricity interconnection with natural gas infrastructure serve the Union's energy diversification goal with a smooth transition to a green energy future.

The potential geopolitical implications are complex and contradictory.[86] On the one hand, an integrated regional electricity system could create geopolitical vulnerabilities for the electricity importers, transforming electricity from a commodity into a political leverage, as in the case of oil or natural gas. On the other hand, greater interconnection could increase the interdependence among states, reducing risks of conflicts or competing attitudes. The key for the prompt deterrence of the first scenario is the adoption of the appropriate regulatory framework that will found electricity integration on the basis of cooperation and common profit.

The technology evolution leads, inevitably, to the digitalization of the energy sector, contributing significantly to the preservation of grids' balance by blurring the boundaries between generation and consumption. Such a capability can make the energy sector more intelligent, efficient and sustainable, but can also raise a significant security and privacy risks. Eventually, cybersecurity could become the number one challenge to the new energy future, where the state will face an unknown threat whether this is a push button or a computer order. However, cybercrime is not a new threat for the international community, so it must not be associated directly

[84] The Covenant of Mayors Initiative for local sustainable energy, (online) Available from: https://e3p.jrc.ec.europa.eu/node/188 (accessed: 02/10/2019)
[85] Baltic Energy Market Interconnection Plan (BEMIP), (online) Available from: https://ec.europa.eu/energy/en/topics/infrastructure/high-level-groups/baltic-energy-market-interconnection-plan, (accessed 2/10/2019)
[86] Supra notes 8 and 69

with the new energy transformation, giving a negative nuance to the transition process. Contrarily, given the fact that states and energy corporations are already aware of this tactic, they can develop effective counter-measures to protect smart grids and related assets from possible cyber-attacks.

The ongoing and widespread adoption of renewables and new green technologies increases, and will continue to do, the demand for a range of minerals and metals, and especially rare earth elements that are essential in the production stage. The technology innovation could enable in a couple of years the mining of these elements even in the seabed, increasing the available reserves. The largest reserves are found in the developing and weak states. According to a view, *countries that dominate the export of rare-earth minerals will be the petro states of tomorrow*.[87] Such a perspective conceals both opportunities and risks affecting radically the formation of international relations and international coalitions. In the following chapter 3, it is attempted a substantive analysis of rare earths intensive use, in order to reflect all the dimensions that arise from their exploitation: technological, economic, political, social and environmental.

The analysis so far is indicative of the potential inherent in the gradual deployment and dominance of renewables and new technology. Despite the difficulties of adapting and coordinating within the pace of continuous growth, the benefits will be greater from the choice of abstention. This is the time of all the states –developed and developing, weak and emerging- to redesign the international geopolitical lines.

[87] O'Sullivan, M., (2017) Switch to Renewables Won't End the Geopolitics of Energy, Available from: https://www.bloomberg.com/view/articles/2017-08-21/switch-to-renewables-won-t-end-the-geopolitics-of-energy, (accessed: 10/06/2018).

Chapter 3

Rare Earth Elements: Energy Security and Insecurity Implications.

3.1. A small introduction on Rare Earth Elements' world.

The rare earth elements (REE) or rare earth metals (REM) or rare earth oxides (REO) are a group of 17 chemically similar metallic elements. The 15 of them constitute the group of lanthanides, which range in atomic number from 57 to 71 on the Periodic Table of elements, along with the metals scandium (atomic number 21) and yttrium (atomic number 39).[88] The last two elements are regarded as rare earths because of their similar physical and chemical properties and typically occur in the same ore deposits with REE.

[88] Balamar, V., (2019) Rare Earth Elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact, Geoscience Frontiers, 10, p. 1285-1303; U.S. Department of the Interior (2014) The Rare – Earth Elements- Vital to Modern Technologies and Lifestyles, U.S. Geological Survey, Fact Sheet 2014-3078.

Traditionally, the REE are divided into two category-groups according to their structure of electron shell,[89] atomic weight and the separation process: light rare earth (LREE: lanthanum, cerium, praseodymium, neodymium and samarium) and heavy rare earth (HREE: gadolinium, europium, terbium, dysprosium, thulium, ytterbium, lutetium, yttrium, holmium and erbium).[90] Each one of the rare earths has taken its name either from the place it was discovered or from the person who discovered it.

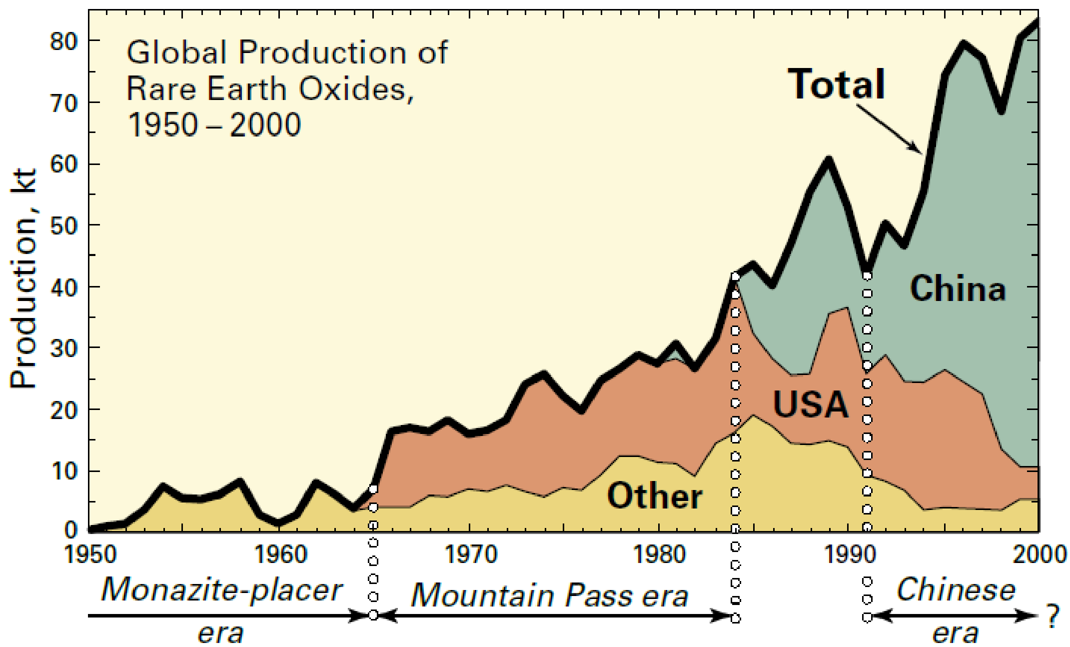
Despite their denomination as "rare", they are in fact in abundance in the earth's crust. Their name came from their identification as "earths" during the 18th and 19th centuries, which in comparison to other "earths", such as lime or magnesia they were relatively rare.[91] However, later discoveries revised the original estimates. Specifically, most of the rare earths are as abundant as copper and lead, while some of them exceed in amount contrary to some easily exploited elements, including the platinum group elements and mercury.[92] What is very impressive, is that rare earths do not exist as individual metals in nature such as gold or silver, but occur together in numerous ore minerals as either minor or major constituents.[93] This is happening because of their reactivity capacity.

REEs are found in a wide range of minerals, including silicates, carbonates, oxides and phosphates and can only be found in a few geological environments. Until today, there have been discovered more than 250 minerals containing rare earth elements in their chemical formula.[94] Consequently, the challenge for the mining sector is to discover the REEs that can be both mined and processed in low-cost. All over the world, there are about 851 rare earth deposits, but only a small part of them has the potential of sufficient geology exploration and even fewer have passed into the production stage.[95]

[89] The LREEs have unpaired electrons in the 4f electron shell and HREEs have paired electrons in the 4f electron shell.
[90] Gambodgi, J., (2015) Rare Earths, U.S. Geological Survey, Minerals Yearbook.
[91] U.S. Department of the Interior (2014) The Rare – Earth Elements- Vital to Modern Technologies and Lifestyles, U.S. Geological Survey, Fact Sheet 2014-3078.
[92] Chen, Y., and Zheng, B., (2019) What happens after the rare earth crisis: A systematic literature review, MDPI, Sustainability, 11, 1288.
[93] Supra note 88.
[94] Balamar, V., (2019) Rare Earth Elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact, Geoscience Frontiers, 10, p. 1285-1303; Chen, Y., and Zheng, B., (2019) What happens after the rare earth crisis: A systematic literature review, MDPI, Sustainability, 11, 1288.
[95] Zhou, B., Li, X., and Chen, C., (2017) Global Potential of Rare Earth Resources and Rare Earth Demand from Clean Technologies.

REEs were first discovered in 1788. The global annual production and consumption of the elements was less than 5,000 metric tons of REO before the decade of 1950.[96] Precisely, until 1948, most of the world's REEs were extracted in India and Brazil.[97] In the 1950s, a small quantity of them were produced from monazite-bearing placers and veins, (with the largest known discovered sources in South Africa[98]) and from pegmatites and carbonatites and by-products of uranium and niobium extraction.[99]

Figure 9



Source: U.S. Department of Interior (2002) Supporting Sound Management of our mineral resources. Rare Earth Elements – Critical Resources for High Technology.

The most significant discovery was made in 1949 at Mountain Pass, in the upper Mojave Desert, California. It was about a carbonatite intrusion with significant content of LREE –more precisely hosted by bastnasite and related minerals. From 1965 to 1985, Mountain Pass was the dominant source of REEs, producing 60 percent of the world's rare earth and ensuring the self-

[96] Ibid.
[97] Mayer Brown, (2014) Rare Earth Elements. Deep Sea Mining and the Law of the Sea, Three Dimensional Thinking.
[98] Ibid.
[99] U.S. Department of Interior (2002) Supporting Sound Management of our mineral resources. Rare Earth Elements – Critical Resources for High Technology, U.S. Geological Survey, Fact Sheet 087-02.

sufficiency of the United States.[100] However, the environmental concerns and the unbeatable lower-prices of China's REEs (whose production has significantly started to increase since 1985[101]) led to the gradual disruption of mining activities in 1998[102] and the final closure of Mountain Pass in 2002.[103] For U.S.A on that time, it was more profitable to purchase China's rare earths than maintain domestic mining capacity.[104] Gradually, this radical overturn paved the way for China to take gradually the lead in all stages of exploitation in this sector. In 2017, the Chinese production has reached the unprecedented allocation of 95% of the total production of REEs in the global market.

As we have already mentioned, REEs do not exist individually in earth's crust, but they generally occur in uncommon geologic rock types and settings; a fact that make exceptional their economic concentration. Economic REEs deposits occur primarily in four geological environments: [105] carbonatites, alkaline igneous systems, ion-absorption clay deposits, and monazite-xenotime-bearing placer deposits. Furthermore, the exploitable deposits can be divided into primary and secondary deposits. Primary deposits are those formed by magmatic, hydrothermal and/or metamorphic processes.[106] This category of deposits is most common and is associated with alkaline igneous rocks and carbonatites, and for that reason they are minded by conventional opencast and underground methods that are used also for hard rock deposits (drilling and blasting).[107] Secondary deposits are the result of weather conditions and in particular the erosion process and may include placers, laterites and bauxites. These deposits are minded in three different ways by dredge mining methods, by manual surface collection and by mechanized dry mining methods using conventional earthmoving equipment.[108]

[100] Smith Stegen, K., (2015) Heavy Rare Earths, permanent magnets, and renewable energies: An imminent crisis, Journal Energy Policy, 79, 1-8.
[101] Supra note 99.
[102] Supra note 94.
[103] Supra note 99.
[104] de Ridder, M., (2011) The Geopolitics of Mineral Resources for Renewable Energy Technologies, This paper was first presented at the workshop "Geopolitics of Renewable Energy" organized by the Hanse-Wissenschaftskolleg – Institute for Advanced Study and Jacobs University Bremen, from 30 November to 2 December 2011, Delmenhorst, Germany
[105] Supra note 91.
[106] Supra note 94.
[107] Kapustka, K., Klimecka-Tatar, D., Ziegmann, G., (2019) The Management and potential risk reduction in. The Processing of Rare Earth Elements, Sciendo, 1:1, p.77-84
[108] Ibid 101, 102

Due to their exceptional magnetic, luminescent, electrochemical and catalytic properties, REEs have acquired a dominant position in everyday life in different areas of interest: electronics, manufacturing, medical science, technology, military defence systems and emerging clean technologies and renewables. For many years they have concentrated, mainly, the academic interest, since their extraction was too costly to be viable on an industrial scale. The technological evolution of mid-20th century worked as an incentive for the industry to start the intensive exploitation of REEs' very useful chemical properties in a wide range of technological applications, which inevitably boosted their strategic value.

The 21st century with a plethora of technological innovations -hybrid vehicles, rechargeable batteries, wind turbines, mobile phones, flat-screen display panels, fluorescent light bulbs, laptop computers, disk drives, lasers, catalytic converters-, undeniably, could be characterised as a Globalised Rare Earth World. The new international guidelines draw a significant shift from traditional energy sources towards clean energy. Furthermore, the gradual dominance of new green innovative technology put forward a higher demand for global production of REEs and make necessary the steady and secure supply in the long-run.[109] Japan, USA and European Countries with their increasing needs for continuing access to rare earths supplies have gradually created a deep dependency bond to China's resources, which has transformed her into a monopolistic power.

The evolutions in the decade of 2010 were radical. The Chino-Japanese dispute over the Diaoyu/Senkaku Islands, the deteriorating ecological environment and the increased needs on REEs supplies after the intensification of investments in clean energy worldwide, have led China to redraw its REEs policy. China's reviewed decisions included a more stringent export policy with reduced export quotas, which immediately raised the prices of rare earths. As it is expected, the REEs' research interest has gradually shifted from academic ground to technological and ultimately to economic and political one, inserting a blank page in the study of international relations.

The international community is confronted with profoundly interconnected changes. The New Energy Order imposes the need to invest in clean energy technologies in order to reduce

[109] Supra note 95.

carbon emissions and achieve a sustainable future.[110] The steadily increasing demand on rare earths in conjunction with the recent developments in China have reinforced their characterization as "critical" or "strategic" materials by the biggest importers and consumers of REEs (US, EU and Japan).[111] The need for secure access to credible sources of energy and the need to eliminate the oil dependency were two forcible arguments of some nations' new energy agenda to shift to renewables in order to achieve independency and self-sufficiency. However, is seems that the new energy transition creates new challenges for the nations. Would it be premature to argue that states are gradually cutting-off their dependency on traditional fossil fuels and create new ones with REEs?

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[110] Leader, A., Gaustad, G., and Babbitt, C., (2019) The effect of critical material prices on the competitiveness of clean energy technologies, Materials for Renewable and Sustainable Energy, 8:8.

[111] Leader, A., Gaustad, G., and Babbitt, C., (2019) The effect of critical material prices on the competitiveness of clean energy technologies, Materials for Renewable and Sustainable Energy, 8:8; Guyonnet, D., Lefebvre, G., and Menad, N., (2018) Rare earth elements and high-tech products, BRGM (French Geological Survey) prepared for Circular Economy Coalition for Europe; McLellan, B.C., Corder, G.D., and Ali, S.H., (2013) Sustainability of Rare Earths – An Overview of the State of Knowledge, MDPI, Minerals, 3, p. 304-317.

3.2. Understanding the Geopolitics of Rare Earth Elements.

3.2.1. There may be a parallel between the fossil fuels and the Rare Earths?

A sticking point for some nations' energy security was their dependence on fossil fuels, as either producers or consumers and transit states. The gradual depletion of fossil fuel reserves, despite the advances in technology (horizontal fracturing) and the discovery of new deposits (pre-salt oil reserves in Brazil, shale oil and gas in US) rings the alarm bell and brings the states into facing the energy deadlock.

The goal and the mainspring of the New Energy Order is the diversification of resources in a one-way procedure to achieve energy security. In parallel, the vision of decarbonized both energy and economy sectors encourages the accomplishment of the objective. The renewable sources emerge as the protagonists of the New Energy Order offering opportunities in a wide range of domains: energy, technology, economy, trade and investment. Their inexhaustible potential confirms their characterization as sustainable source of energy.

However, the oxymoron in the case of Renewables is that, although they are endless and recyclable sources of energy, they rely on finite sources –the rare earth and other limited minerals- for the construction of the renewable installations. Is this reality a crack in the achievement and preservation of diversity? Could it be possible to exist a common point between the fossil fuels and rare earth elements?

First, REEs as fossil fuels are finite reserves. The rapid technological development and innovation compelled the systematic use of rare earths. According to the static paradigm[112] on fossil fuels, the speed of extraction and demand rates determine the rate of depletion. In case of REEs, it has been identified an explosive rise in their demand during the last three decades. A wide

[112] Kooroshy, J., Korteweg, R., de Ridder, M., (2010) Rare Earth Elements and Strategic Mineral Policy, The Hague centre for strategic studies & TNO, Report No 2010-02.

range of technology devices are in need of these materials because of their unique magnetic, phosphorescent and catalytic properties. Indicatively, computer memory, DVDs, rechargeable batteries, autocatalytic converters, super magnets, mobile phones, LED lighting, superconductors, glass additives, fluorescent materials, phosphate binding agents, solar panels and magnetic resonance imaging (MRI) agents. As the world population and the consumption per capita of the products mentioned before will continue to rise, and the energy sector will foster the acceleration of renewables, we are led to a direct impact on the demand rate for REEs. The pace of consumption and exploitation of the rare earths in relation to the total exploitable reserves, along with further technological advances will indicate REEs potential operating time.

Many countries are highly dependent on mineral imports as in the case of fossil fuels. According to Jane Nakano of the Center for Strategic and International Studies, *"the degree of reliance depends upon where each economy sits along the supply chain."*[113] What makes rare earths a unique case is that import states have established a deep dependency bond with China, who has been monopolizing the market for the past 20 years or more. The intense concerns of environmental degradation during the mining process led many countries to abandon their exploitation projects (USA, Mountain Pass). On the other hand, in the early 1970s, China considered REEs as one of her strategic priorities. Furthermore, the low-cost labour and the absence of environmental regulations contributed to the explosive increase in China's productive output, with an astonishing annual growth rate[114] of 40% during the period 1978-1989, reaching the 11,860t, within this decade.[115]

The concentrated production of REEs in a few states with a leading role of China has raised a deep sense of insecurity among the import dependent states about supply risks.[116] Supply disruptions may be accidental because of political instability or even intentional when they serve as a political leverage. In case of REEs, import states realized the level of their dependence on China's exports just in 2010. After the Chino-Japanese conflict, China decided to follow a more

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[113] Webster, G., (2011) Rare Earth Elements, Asia's Resource Nationalism, and Sino-Japanese Relations. Interview with Yufan Hao and Jane Nakano. The National Bureau of Asian Research (online) Available from: https://www.nbr.org/publication/rare-earth-elements-asias-resource-nationalism-and-sino-japanese-relations/ (accessed 20/10/2019).

[114] Hurst, C., (2010) China's Rare Earth Elements Industry: What Can the West Learn? Institute for the Analysis of Global Security (IAGS).

[115] De Medeiros, C. A., and Trebat, N.M., (2017) Transforming natural resources into industrial advantage: the case of China's rare earth industry, Brazilian Journal of Political Economy, vol.37, Nº3 (148) p.504-526.

[116] Supra note 103.

stringent export policy, reducing significantly the export quotas. This fact was indicative of the new economic dimension of rare earths, launching a new page in both research and policy agendas of nations.

From then onward, the fear of supply risk and the volatility of prices of REEs have motivated nations to examine their alternatives policies and choices. The price of REEs became a determinant factor in the strategy they will ultimately choose: importing from china or investing in exploring in other countries' rare earth resources.[117] The need for diversity of resources was confirmed once again.[118]

Since economic and technological security are part of national security, it would not be unreasonable, on behalf of import dependent countries with an advanced technology based on rare earths, to detect political choices with an intention to securitize their mineral trade. Their potential choices are concentrated in the following triptych: 1) signing of strategic bilateral agreements or joint ventures in resource countries, 2) searching and investing on alternatives that will mitigate the need for primary REEs (substitutes or recyclable products) and 3) finally, using the most excessive measure of military power in order to secure the supply chain against intentional disruptions.

The consequences of financial debt crisis in Europe and USA have had a major impact on political leadership's perception. In many countries, we identified measures of deregulation, privatization, trade and financial liberalization,[119] which enhanced significantly the role of state, giving rise to state capitalism. Subsequently, China's new policy on rare earths trade, into the context of a more protective international environment, confirmed trends to resource nationalism.

Resource nationalism has a double effect.[120] On the one hand, it refers to a situation where domestic state-owned companies take the control over natural resources excluding foreign investors. On the other hand, governments align their natural resource policies more explicitly with the national interest, as in the case of many petro-states.

[117] Supra note 92.
[118] Trilateral EU – Japan – U.S. Conference on Critical Materials for a clean energy future. Washington DC, 4-5 October 2011.
[119] de Ridder, M., (2011) The Geopolitics of Mineral Resources for Renewable Energy Technologies, This paper was first presented at the workshop "Geopolitics of Renewable Energy" organized by the Hanse-Wissenschaftskolleg – Institute for Advanced Study and Jacobs University Bremen, from 30 November to 2 December 2011, Delmenhorst, Germany
[120] Ibid.

The case of China with the peculiar political model of state-led economic growth without political liberalization, and her policy reorientation on rare earths after 2010 (restriction in export quotas), brings together all the features of resource nationalism. Furthermore, in a more general context, as state capitalism is gaining ground in emerging and developing economies, resource nationalism is going to characterize even more national policies, especially of those states that now understand the prospect that could arise through exploiting and trading their rare earths' resources.

Therefore, are we on the way of a new form of the resource curse phenomenon[121]? In view of the fact that we are at the beginning of the Energy Transition, the ongoing promotion of Renewable Sources will increase demand and dependence on advanced raw materials, which in their turn will affect the supply index. For many countries, this could be a great chance to develop exploitation REEs programs and participate in the supply chain by exchanging significant rents. In the case of states such as Myanmar, Burundi, Vietnam, with weak economies and political systems, a diverse connection of their GPD with the exploitation and trade of rare earths could lead to an overall shape of the economy according to the oil and gas patterns of the past.[122] Such a possible scenario renews the vicious cycle of oil in international relations, creating bonds with finite elements, leading to weak economies and an ongoing resource competition with intense prospects of conflicts.

Moreover, in the battle for new rare earths reserves, regions with large unexploited mineral reserves, such as the Arctic region and the South China Sea[123], will gain enormous interest by upgrading themselves into strategic importance points. The traditional oil chock points: Strait of Hormuz, Strait of Malacca, Cape of Good Hope, Bab el-Mandap, Danish Straits, Suez Canal, Bosporus, Panama Canal, will gradually give way to new ones in Greenland (with the potential to become one of the largest suppliers of critical rare earths such as neodymium, terbium, dysprosium, yttrium, lanthanum and cerium), Bolivia, Kazakhstan and Mozambique.

To sum up, by studying and analyzing in depth the new geopolitical formations that emerged from the intensified exploitation of rare earths, it can be identified the new international environment that is evolving. The parallelism of rare earths with fossil fuels highlights the

[121] The phenomenon of resource curse refers to a national economy with plentiful resources that has lower GDP growth and long-term low development in relation to a national economy with fewer resources.
[122] O' Sullivan, M., Overland, I., Sandalow D. (2017) The Geopolitics of Renewable Energy, Columbia SIPA, Harvard Kennedy School, Norwegian Institute of International Affairs, Working Paper June, USA.
[123] Supra note 119.

criticality of the first one for international supply chain and trade under the New Energy Order. Definitely, the available REEs resources redefine the relative power of states in the international system. However, this is not enough. The states with technical potential for renewables and the leader states in technological innovation are equally indispensable players in the new energy transition, sharing an equal position of power.[124]

The challenge of securitization of minerals could threaten the higher goal of energy transition, this of energy security. A safe access to minerals resources is the number one prerequisite for a succeeded transition to clean energy technology. Therefore, governments have now obtained a great advantage due to its knowledge of the fossil fuels' pathogens, in order to avoid same old mistakes.

[124] Global Commission on the Geopolitics of Energy Transformation (2019) A New World. The Geopolitics of the Energy Transformation, International Renewable Energy Agency.

3.2.2. Under the threat of a supply risk?

On the one hand, the usefulness of rare earths in new technologies (clean energy, high tech military components and electronics) and on the other, their potential for supply disruption,[125] as well as their environmental impact dimension [126] advocate their characterization as critical elements.

Already since 2008, a significant number of panels and agencies have underlined their potential to trigger new tensions among states.[127] To name some of them; National Research Council, U.S. Department of Energy, European Commission, American Physical Society and Materials Research Society and the Resnick Institute. However, it was just the Chino-Japanese incident that confronted the international community with the eventuality of a rare earth crisis.

On September 7, 2010, Japanese fishing boats along with the Japanese Coast Guard detected a Chinese fishing near the disputed area of the Senkaku Islands in the East China Sea, and accused the fisherman of violating the Japanese territorial waters. The collision and subsequent detention of the fisherman from the Japanese authorities arrived at a major diplomatic dispute between the two involved countries. When China's repeated demands for the release of the Chinese citizen were refused, she decided to freeze the official meetings with its Japanese counterparts of the ministerial level and above. In addition, on September 23, in a demonstration of power and pressure on the Japanese government, China ceased its exports of rare earth elements to Japan.[128] China's severe response was a serious damage to Japan's high-tech industry, forcing her, finally, to release the arrested fisherman. The reactions over the incident were plentiful. From the Chinese side was a diplomatic victory, while the operations of Japanese government on the issue have been the subject of an intense domestic criticism. Finally, the international community and many

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[125] Supra note 109.

[126] Bradsaw, A.M., Reuter, B., Hamacher, T., (2015) Could the extensive use of rare elements in renewable energy technologies become a cause for concern? EPJ Web of Conferences 98, 04007. (online) Available from: http://www.epj-conferences.org/ (accessed: 13/04/2019).

[127] Supra note 91.

[128] Livergood, R., (2010) No22: Rare Earth Elements: A Wrench in the Supply Chain? Center for Strategic and International Studies, Defense-Industrial Initiatives Groups (online) Available from: https://csis-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/101005_DIIG_Current_Issues_no22_Rare_earth_elements.pdf, (accessed: 29/092019) ; Gholz, E.,(2014) Rare Earth Elements and National Security, Council on Foregn Relations, Energy Report, U.S.

observers debated whether it was an attempt from China to gain political leverage over Japan or a decision arrived from domestic concerns pushing for policy reorientation.

This bilateral event coincided with a complete change in China's export policy. The government's decision to reduce its total export quotas at a percentage of 40%[129] was a combination of different factors,[130] apart from the Chino-Japanese incident. In particular, the fact that REEs are finite elements in combination with a deteriorating ecological environment compelled as necessary the redefinition of the REEs' exploitation policy under a more sustainable pattern. Furthermore, the increase of domestic demand and the need for sufficient future supplies for her industrial sector was one more reason that led to the restriction of exports but not of the production rate, which continued to be high.

The main goal of the Chinese policy concerned the clearance of intrinsic pathogens of its industry sector. Up to that time, the production of rare earths was not controlled by the state, but it was organized under a special regime, known as decentralization of enterprise reforms.[131] That situation favored the participation of even small, privately owned enterprises, most of which had little or no awareness of the measures should be taken during the mining and processing stages in order to prevent or manage the environmental burden. Chinese government decided to stop the administration of new licenses to small businesses and promote the gradual amalgamation of small businesses and workshops into larger state-owned enterprises. In addition, under this policy, government could, also, control and eradicate the illegal production of rare earths.[132] Chinese exports from illegal mining activities constitute a threat not only for China but also for the international trade, by jeopardizing the economic viability of possible projects outside of China, and by violating basic rules of uncorrupted competition. Indeed, according to a paper from the French Geological Survey, prepared for the Circular Economy Coalition for Europe, Chinese rare earth output in 2016 from illegal mining was somewhere between 45,000 and 95,000 tons.[133] The

[129] McLellan, B.C., Corder, G.D., and Ali, S.H., (2013) Sustainability of Rare Earths – An Overview of the State of Knowledge, MDPI, Minerals, 3, p. 304-317.

[130] Chen, Y., and Zheng, B., (2019) What happens after the rare earth crisis: A systematic literature review, MDPI, Sustainability, 11, 1288 ; Webster, G., (2011) Rare Earth Elements, Asia's Resource Nationalism, and Sino-Japanese Relations. Interview with Yufan Hao and Jane Nakano. The National Bureau of Asian Research (online) Available from: https://www.nbr.org/publication/rare-earth-elements-asias-resource-nationalism-and-sino-japanese-relations/

[131] Supra note 112.

[132] U.S. Department of Interior (2002) Supporting Sound Management of our mineral resources. Rare Earth Elements – Critical Resources for High Technology, U.S. Geological Survey, Fact Sheet 087-02.

[133] Guyonnet, D., Lefebvre, G., and Menad, N., (2018) Rare earth elements and high-tech products, BRGM (French Geological Survey) prepared for Circular Economy Coalition for Europe.

internal remediation would facilitate the establishment of integrated and innovative Chinese corporations with the potential to compete globally under equal terms.[134] Furthermore, the increase of domestic demand and the need for sufficient future supplies for her industrial sector was one more reason for the restriction of exports but not of the production rate, which continued to be high.

Despite China's leadership in global REE production and exports, she has presented a constraint competitiveness. This fact was the result of the low added value of the products. In 2010, the global rare earth industry worthed an estimated $1.3 billion, while the end-use industries that required rare earth worthed an estimated $4.8 billion. According to Chinese officials, the uncertainty over the supply of rare earths could lead a number of end-use manufacturers to move their factories in Inner Mongolia (the area of rare earth applications). This new policy orientation would have two impacts. On the one hand, it would increase the foreign investments in Chinese territory[135] and on the other, the investors would achieve a secure and uninterrupted access to Chinese stocks. Such a scenario would transform Inner Mongolia into an industrial area, with China enjoying full control of rare earth industry and rare earth end products, as well as offering more jobs to her people.[136]

Nonetheless, the great importers of Chinese rare earths (U.S.A, E.U, and Japan) did not consider the change of China's export policy to be a great opportunity for their end-use manufacturing industries to attract their investment interest. Contrariwise, the whole world was confronted with a rough reality: their strong dependence on China's exports due to its over 90% share of the world's demand. The decline in global export quotas has led to a dramatic increase in prices and a general insecurity, triggering new discussions in the field of potential REEs supply risk.[137]

In 2011 the European Union, the U.S and Japan, initiated the first "Trilateral Conference on Critical Materials"[138] under the participation, also, of Canada and Australia in order to delve more deeply their alternatives in occasions of future shortages. In 2012, the founding members of the

[134]Chen, Y., and Zheng, B., (2019) What happens after the rare earth crisis: A systematic literature review, MDPI, Sustainability, 11, 1288.
[135] Supra note 132, 134.
[136] Supra note 114.
[137] Supra note 134.
[138] Supra note 116.

Trilateral Conference[139] appealed to the Dispute Settlement Body of the World Trade Organization filing a complaint against China's decision to restrict its export quotas. After about two years, in March 2014, the WTO adjudicated that China had violated international law by restricting overseas exports.[140] Consequently, China was forced to annul its export restriction policy, including the export quota and export tariff.

It follows that, China's policy change not only did she not produce the expectable results, but also it triggered a series of academic and political research into possible alternatives (substitutes or recycling products) highlighting the critical and strategic nature of the elements. In parallel, there were a number of surveys focused on the identification of different possible scenarios that can lead or trigger a supply risk.[141]

As the new Energy Transition provides it, the new green technologies are essential tools in the battle against carbon emissions while contribute to a more sustainable future. Rare earths are the key elements in the diffusion of green technologies (clean energy, defense, electronic or healthcare technologies). The danger of a supply risk because of limited export availability is just one aspect of the coin. Further researches on the issue have indicated a number of other important reasons.

As it is already known, the unique physical and chemical properties of rare earths make them indispensable and in some occasion non-substitutable for the emerging technologies. The difficulty of substitution due to its unique properties or even the low availability of a material from recycling steams are two main instances of a possible supply risk because of the special nature of REEs.

In chapter 3.1., it was attempted a brief introduction to rare earths with regard to their properties and their extraction methods. As it has been already mentioned, REEs do not exist as individual metals in nature, but occur together in numerous ore minerals as either minor or major constituents. During the simultaneous mining process of rare earth and non-rare earth elements, it is possible for the first one to be extracted as a by-product of the second one, resulting in the weakening of their properties. Finally, despite the fact that rare earths are not as rare as we thought years before, some very critical materials, such as dysprosium or neodymium, are located in a limited number of constituents.

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[139] European Union, U.S. and Japan.

[140] World Trade Organization, China-Measures related to the expropriation of rare earths, tungsten and molybdenum: WT/DS431/17, WT/DS432/15, and WT/DS433/15.

[141] Supra note 109, 125, 127, and 134.

Indeed, Dysprosium and Neodymium are HREEs found in ion adsorption mines, and specifically in Bayan Obo, China and in even limited quantity in Mountain Pass, California. Dysprosium is an important component of advanced permanent magnets ($Nd_2Fe_{14}B$). It increases the coercivity and extends the temperature range in which magnets can operate ($200^{O}C$).[142] Furthermore, it can increase efficiency for the manufacturers, offering lower costs and shorter payback periods.[143] This kind of magnets have an extensive use in electric motor in battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs) and in wind turbines. As it is provided, magnets, electric vehicles and wind power are the primary emerging technologies[144] dominating in future rare earth demand, becoming the number one argument for states to invest in initiatives in order to eradicate the threat of a possible supply risk.

After 2010, there is a renewed interest for the reopening of the closed mines or the opening of new ones. Some of the new mining ores are located in geographically unstable states, a fact that gives rise to concerns over the credibility and security of supply.

The demand for many critical materials is expected to continue to grow in the future in a rapid pace, alongside, with the growth of the world population and improved living conditions on even more developing states. This in turn, will affect the GDP per capita of states with a direct impact in the upward trend of electronic sales. The parallel adoption and expansion of clean energy will lead to a higher demand boosting the criticality of some very essential elements. The risk of extreme price peaks or even possible elements' unavailability are the bad scenarios of a possible disruption of the supply chain intensifying the fear of energy insecurity.

From the above analysis, we realize that both governments and businesses,[145] in order to avert future supply disruptions and maintain the prices in a level that does not threaten the competitiveness of the market, should respond appropriately. In addition, the eradication of the risk for potential supply deadlocks enhance the interest for more investments in the new technology with a lower risk.

From the business sector side, new investments should be concentrated on finding suitable substitutes, new recycling methods, dematerialization of the end-products and the improvement of

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[142] Supra note 125, 134.
[143] Smith Stegen, K., (2015) Heavy Rare Earths, permanent magnets, and renewable energies: An imminent crisis, Journal Energy Policy, 79, 1-8.
[144] Supra note 133.
[145] Leader, A., Gaustad, G., and Babbitt, C., (2019) The effect of critical material prices on the competitiveness of clean energy technologies, Materials for Renewable and Sustainable Energy, 8:8.

product lifespan. Through the dematerialization it will be required fewer use of the given critical material in a particular technology per functional unit. In order for this option to be implemented efficiently, businesses should, firstly, invest in innovation and in ongoing improvement of the existing technology. The expansion of product lifespan has both economic and social effects. Since the product will have a longer period of use, the business will need less of the appropriate critical material for the construction of the end-product. In consequence, a business that does not drain the natural resources for its ongoing production is preferable to the customers. In the medium term, such a policy has a major two-effect. On the one hand, it diminishes the fear of a potential future supply risk, and on the other, it succeeds in expanding its consumer community, because it provides the market with a product reliable, innovative and environmentally friendly.

The role of state should be encouraging and supportive. New regulations and research programs from the government side should incentivize clean energy technology adoption, under total harmony with the goals of the international community for decarbonization and mitigation of climate change consequences.[146]

The reoperation of closed mines or the opening of new ones should be done in the proper way, following the appropriate measures in order to avert the environmental deterioration. Since it can take a decade for a new mine to be operational,[147] the policy-makers should support investments that promote sustainable development and environmental protection. After all, this is the ultimate goal and challenge of the new Energy Transition.

According to recent studies, there are significant REE resources in the sediments of continental shelf and ocean bottom. In Bayan Obo, a significant quantity of HREEs was discovered, followed by the initial exploration of seabed sources.[148] The rare earth resources of continental shelf and deep oceans can be distinguished into three types:[149] polymetallic nodules, ferromanganese crusts and deep-sea muds. However, mining of seabed rare earths is in the early stages of research and will take years to become operational and part of the productive chain.

In the following chapter will be analyzed the alternatives of substitution and recycling, presenting all the advantages and disadvantages.

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[146] Ibid.
[147] Supra note 143.
[148] Supra note 143.
[149] Balamar, V., (2019) Rare Earth Elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact, Geoscience Frontiers, 10, p. 1285-1303.

3.2.3. Are Rare Earths actually rare?

In the face of competition: substitutes or recycling elements?

The world of technology and innovation is moving in a parallel motivation. From the one point of view, the New Energy Order encourage investments in green technologies based on the use of REEs. On the other side, under the concern of supply distortion and prices spikes, it arises the need to find substitutes in order to achieve the diversity of supplies in a sustainable manner. A significant number of studies is concentrated either in reducing the amount of REEs usage or promote alternative material, which tend to have similar properties to rare earths.[150]

As technology was evolving and the electronics industry were discovering the multifaceted utility of rare earths in new achievements, the rare earths' ongoing research aimed at optimization in order to be achieved an even broadened scope of usage.[151] Nonetheless, after 2010 and the china's quota reductions, research and development studies were concentrated in founding alternative materials or eliminating rare earths' use.

A number of surveys concentrated to find substitutes in the family of rare earths have confirmed that not all the REEs have same properties or purchase cost. For instance, as has characteristically being mentioned by Karen Smith Stegen, terbium could be used as a substitute for dysprosium in permanent magnets. However, it is unprofitable because of its even bigger cost. Praseodymium could only partially substitute neodymium in magnets, since it could not support high performance magnets that are used in vehicles and wind turbines. Yttrium could, also, applied as a substitute to permanent magnets, since it is used in high- temperature superconductors. However, such a scenario would increase the demand for terbium, creating supply problems, despite it constitutes the 62% of the entire HREE resources.[152]

A significant number of major corporate giants[153] have already started searching on finding substitutes to REEs. Specifically, Hitachi Metals is examining a new magnet of low REE use by employing copper alloys. Toyota is developing future hybrid vehicles of no REEs use. Samsung,

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[150] Ibid.
[151] Supra note 143.
[152] Zhou, B., Li, X., and Chen, C., (2017) Global Potential of Rare Earth Resources and Rare Earth Demand from Clean Technologies
[153] Supra note 143, 149.

also, is trying to find rare earth alternatives in its applications, while in 2014 succeeded in developing a new wind power generator without any Dysprosium, by integrating a cooling system as a regulator of the high temperatures developed during the operation of the turbines. Howbeit, Mitsubishi's prime efforts to create an electric motor of no REEs concluded to a new less efficient than conventional one.

The innovation efforts of the private business sector are accompanied and supported by their governments, too. Both the U.S. Department of Energy (U.S. DOE) and Japan's Ministry of International Trade and Industry (MITI) have been funding many projects (public and private) for this purpose.[154] The U.S. DOE funded the Critical Materials Institute (CMI) in order to conduct researches on a range of alternatives from diversification of suppliers to develop substitutes, recover REEs from other commodity process stream and improve reusing and recycling rates.[155]

CMI in collaboration with General Electric and Lawrence Livermore and Oak Ridge National Laboratories developed new fluorescent lighting phosphors using less REEs than current technology.[156] Furthermore, CMI, Oak Ridge and Idaho National Laboratories developed a new technology for the recovery of REEs. The U.S. Rare Earths, INC., under CMI's authorization, was the first to apply the new technology to old electronics and mineral concentrates.[157]

The Japanese government in 2011 has launched a new policy with a time horizon of 2030 named as "Reduction and replacement of rare earths and rare metals." This policy actuated a great number of companies to experiment with the construction of new low-dysprosium permanent magnets. In parallel, a new magnet recycling program was introduced.[158]

Since 2008, the "European Raw Materials Initiative" has introduced the necessity for European industry to create new cooperation ties with other producing countries except of China, contributing to the sustainability and equity of supplies for global markets.[159] In 2015, the Raw Materials Initiative was updated to the standards of UN new sustainable development agenda. In

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[154] Supra note 143.
[155] Gambodgi, J., (2015) Rare Earths, U.S. Geological Survey, Minerals Yearbook.
[156] The new phosphors included a green phosphor, which reduced the terbium (Tb) content by 90% and eliminated Lanthanum (La), and a red phosphor that eliminated both Europium (Eu) and Yttrium (Y).
[157] Ibid.
[158] Chen, Y., and Zheng, B., (2019) What happens after the rare earth crisis: A systematic literature review, MDPI, Sustainability, 11, 1288.
[159] Communication from the Commission to the European Parliament and the Council (2008) The raw materials initiative – meeting our critical needs for growth and jobs in Europe, COM (2008) 699 final.

combination with the European innovation partnership on raw materials,[160] both these two initiatives represent the European Commissions' efforts to ensure a sustainable supply of these materials.

In addition, after the ERECON Conference,[161] in 2014, where European Commission has brought together experts of different fields, has been conducted an overall picture of the "criticality" of rare earths. The three Working Groups were focused on three special areas: (1) opportunities and road blocks for primary supply of rare earths in Europe; (2) European rare earths resource efficiency and recycling; (3) European end-user industries and rare earth supply trends and challenges. The main goal of that Conference was to identify the challenges and opportunities of European Union to participate in the supply chain development of rare earths through recycling initiatives and projects.

The rare earths recycling could be a good alternative in demand gaps, especially for states that have a few or no reserves, as in European Union's case. However, rare earths' unique properties not only make difficult their primary extraction, but also make difficult REEs' recovery from used goods. A significant number of researches on recycling issue focuses on to find alternative methods for extracting materials, as well as, to find new production methods of end-products that will facilitate REEs' future recovery.[162]

There are different methods of recycling and each of them is relatively difficult because of the structure complexity and the electrochemical activity of REEs. During the recycling process, they could be released hazardous components that entail high health risk for the workers and environmental aggravation.

According to Gerhard Ziegman et all, both the manual segregation of components and the mechanical dismantling and shredding could be very harmful for the workers. In addition, the leaching processes use liquids such as nitric acid regia and they could cause a reaction of nitrogen oxide or chlorine gases formation resulting to significant human and environmental impacts. Finally, the thermal processes can result in air emissions, liquid waste and solid waste streams.

[160] European Commission, The European innovation partnership (EIP) on raw materials, (online), Available from: https://ec.europa.eu/growth/sectors/raw-materials/eip_en/ (accessed: 10/10/2019)
[161] A report by the European Rare Earths Competency Network (ERECON) (2015) Strengthening the European Rare Earths supply-chain. Challenges and policy options, Ref. Ares (2015) 2544417.
[162] Supra note 143 and 149.

Consequently, the possible dangers could only be avoided if the protection rules and principles of cleaner production are fully adhered to.

Recycling sources can be divided into three categories[163]: (1) direct recycling of pre-consumer manufacturing REE scrap/residues; (2) urban mining of post-consumer End-of-life products; (3) landfill mining of historic urban and industrial waste residues containing REEs. The recycling rates are recording very low percentages and this is because of inefficient collection, technological difficulties and a lack of incentives to both companies and individuals.

For instance, it is estimated that approximately 50 million metric tons of e-waste are disposed in landfills around the world each year, with only a 12.5% being finally recycled.[164] The difficulty of detecting RRE in devices as small as smartphones, lead to a limited recycling interest. Only if the REEs' recycling became a mandate or the prices of REEs spiked again, it would be a serious argument in favour of recycling.

On the other hand, the recycling of electric vehicles and wind turbines is considered a more economical and feasible option for the recycling companies because of their huge mass.[165] Nonetheless, the newly installed turbines will not be available for recycling for many years. In addition, the absence of "standard methods of recycling rare earths" has limited the interest to invest in recycling methods. The ongoing research on methods into the recovery and recycling of REEs offers, only, a hopefull opportunity in the long run.

In the aggregate, the recycling option presents significant advantages. First, recycling helps to avoid many of the environmental emissions associated with primary ore extraction and processing (radioactive elements: thorium and uranium). Secondly, it promotes the sufficient use of natural resources by ensuring the supply of these critical raw materials for all states, even for them that do not possess rare earth resources. In a way it is safeguarded the self-sufficiency of states, which represents a very important dimension of new energy transition. Thirdly, it provides a great solution in the supply and demand function, addressing the balance problem.

As have already mentioned Guyonnet and all,[166] *deposits rich of LREE are much more common than deposits of HREE. A typical distribution of rare earths in an average LREE ore is:*

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[163] Binnemans, K., and all (2013) Recycling of rare earths: a critical review, Journal of cleaner production, 51, 1-22.
[164] Supra note 149.
[165] Supra note 143.
[166] Guyonnet, D., Lefebvre, G., and Menad, N., (2018) Rare earth elements and high-tech products, BRGM (French Geological Survey) prepared for Circular Economy Coalition for Europe.

50% Ce, 20-25% La, 12-20% Nd and 4-5% Pr. Following extraction, separation processes are used to produce individual rare earth oxides. This distribution of REE in ores generates an imbalance between rare earth supply and demand: in order to obtain one ton of Nd, approximately two tons of Ce and at least as much La must be produced, which leads to an oversupply of Ce and La and directly affect prices. Furthermore, Nd ans Pr in combination with some elements of the category of HREE are used in the construction of permanent magnets that are used in many applications from smartphones to wind turbines. This disproportional demand, which is expected to broaden, creates a balance problem that leads to an ongoing increase of the breadth of criticality and supply risk for some of the rare earths elements category. From this point of view, the recycling of "extra-critical" elements would be an excellent idea towards a threat of a supply limitation or even depletion.

On the other hand, the current disadvantages of current recycling technology provide an argument for greater research in this field. The multiple and ongoing recycling cycles maybe lead to the dilution of rare earth elements having a direct impact on the resource efficiency. The overall loss of their unique functional properties make them deadwood for the new technological applications. Furthermore, it should be minimized the possible environmental degradation as well as the possible impact to other critical elements and resources from the ongoing rare earth recycling cycles. Finally, as it was mentioned before, the failure of massive collection and the cost of dismantling of some end products discourage any attempt to promote recycling.

The role of governments in this endeavour is catalytic. Every state should establish the appropriate regulation that will promote recycling, offering incentives to both individuals and companies to make it a habit of their daily life according to the sustainability manner. However, it is understood that both substitutes and recycling are alternatives that will bear fruits in the medium and long – term. In the short – term, states should reassess their trade ties with China and invest in alternatives and new cooperation with other smaller rare earth producers. The monopolizing character of rare earths market led the international community to the ultimate China's dependency. The gradual liberalization of the market with the entrance of new players could bring the balance in REE market creating a stable and secure environment for further investments.

3.2.4. China and the Other Nation States.

In 1927, Ding Daoheng, a Chinese professor and well-known geologist, discovered iron-niobium deposits at Bayan Obo, in Inner Mongolia and in the following 7 years it was confirmed the mine's content of both bastnaesite and mozanite results. In the 1950's, after the conduction of a detailed geological survey, it started the building and operation of the mine under the Baotou Iron and Steel company.[167] In the following years, more bastnaesite deposits were found in Weishan Country, Shandong (1960) and in Mianning Country, Sichuan (1980).

From the early 60s, China's government has decided to invest in enhancing the use of Bayan Obo. The main argument of that decision was her effort to establish a solid rare earth industry. In parallel, it was given particular emphasis on enhancing the academic research on rare earths' dimensions and exploitation applicability. A great number of institutes and laboratories were founded with the participation of universities and domestic companies aiming at fostering research and development initiatives.

In 1963, it was established the Baotou Research Institute of Rare Earths (BRIRE), run by Baotou Iron and Steel. The General Institute for Nonferrous Metals (GRINM) was sponsored by the company GRIREM Advanced Materials. Furthermore, in the coming years they were established the Sate Key Laboratory of Rare Earth Materials Chemistry and Applications, associated with Beijing University's College of Molecular Engineering and the State Key Laboratory of Rare Earth Chemistry and Physics under the direction of the Chinese Academy of Sciences (CAS). Finally, it was founded the newest State Key Laboratory of Rare Earth Resource Utilization under the Ministry of Science and Technology, which was staffed by two CAS academicians and 20 professors.

The intensification of research and the allocation of significant public funding in new mining and processing technologies, as well as R&D initiatives attested the gradual, but rapid development of the Chinese rare earth market from the period of 1970s to 2000s.[168] More specifically, in 1970s, China exported only rare earth minerals concentrates. In the 1980s, she

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[167] Hurst, C., (2010) China's Rare Earth Elements Industry: What Can the West Learn? Institute for the Analysis of Global Security (IAGS).

[168] De Medeiros, C. A., and Trebat, N.M., (2017) Transforming natural resources into industrial advantage: the case of China's rare earth industry, Brazilian Journal of Political Economy, vol.37, Nº3 (148) p.504-526.

started to export mixed rare earth chemical concentrates, while in 1990s the Chinese firms went one-step further in exporting separated rare earth oxides and metals. The late 1990s and early 2000s, China has committed to consolidate both its upstream and downstream sectors by introducing to the global market rare earth end-products like permanent magnets, phosphors and polishing powder, electric motors, cell phones, computers, batteries and liquid-crystal displays.[169] It is obvious, that just in three decades China maintained to gain a significant comparative advantage over the other states.

China's strategic goal was to benefited from its comparative advantage in the long run and become a world leader in high-tech innovation. The national technology project, known as Program 863/1986. Three Chinese scientists proposed it and it was funded by the central government covering a wide range of technology innovations (biotechnology, space, information, laser, automation, energy and raw materials). The basic goal of the program was the acceleration of useful technologies both to military and civilian applications.[170] A review program on rare earth research was initiated in 1997 (Program 973) with the purpose to meet state's technological needs.

The Chinese policy on rare earth along with both the elimination of rare earth processing and production capacity abroad contributed to the emergence of China as a monopolistic power. The Chinese leader Deng Xiaoping summarized the Chinese policy in this sector up in a famous statement *"There is oil in the Middle East; there is rare earth in China."*

The strategic importance of rare earth for China is confirmed again by the fact that domestic legislation had banned foreign investment in rare earth mining. The Chinese legislation allowed, only, the signing of Joint-ventures contract of common domestic and foreign interest. Furthermore, it was required the assent and the approval of National Development and Reform Commission and the Ministry of Commerce in order for the signed contract to come into force.

As it has already been mentioned in a previous chapter 3.2.2, the rare earth market shared a low added value in comparison to the end-products containing REE. Despite China enjoyed a monopolistic position in REE production and processing chain, she has decided to maintain a fair low purchase price until the early 2000s. The reasons for this situation can be found in a variety of factors. One reason is the fact that most of the REE applications require very small amounts of REEs (for instance, smartphones). Furthermore, for the great importers of rare earths, taking into

[169] Ibid.
[170] Supra note 168, 169.

consideration the wide range of economic and environmental obstacles, was more economically to import the Chinese's products than invest in their own resources. These two arguments were strong enough for China to maintain prices in low-level ensuring long-term importers of its supplies.

Without doubt, China's domestic pathogenies had affected the final purchase price, too.[171] On the one hand, the illegal exploitation of REEs led to an oversupply and a smuggling boom. On the other, the domestic market structure with the participation in the mining and production process of even small businesses and laboratories, as well as the distribution of resources across 22 provinces and regions throughout the country, it made impossible the absolute control of the resources and the initiation of a pricing alliance.

Both the distinctive status of foreign participation in the Chinese domestic projects and the low level of price are indicative of China's intent to control the supply chain development. In the prospect of the ongoing technological advance, the need for critical elements would increase even more, especially in the developed industrialized countries. China's vast resources could be a reliable supplier, almost indispensable as rare earths in new green technologies.

Further, the appearance and gradual acceleration of renewable energy sources accompanied with the climate change goals and decarbonization policies were increasing even more the demand of these elements abroad. However, apart from the external demand for REEs, the domestic demand was increasing rapidly leading China in a deadlock and highlighting the need for a redefinition of its domestic policy.

After 1980s and more systematically after 2000s, Chinese government started to invest on clean energy and renewable energy sources in order firstly, to achieve the decarbonisation of energy sector, secondly to reduce its dependence on coal power plants and finally to succeed on its climate change goals. From 2007 to 2010, China was the leader investors in renewable energy projects. Chinese investments on the sector reached the $120-160 billion.

This energy evolution has benefited the domestic manufacturers ensuring for them a direct access to abundant and low-cost REE supply. As a result, it was a recorded an astronomical increase in investments.[172] In 2005, domestic wind turbine manufacturers produced only 28% of

[171] Chen, Y., and Zheng, B., (2019) What happens after the rare earth crisis: A systematic literature review, MDPI, Sustainability, 11, 1288.
[172] Supra note 169.

turbines sold in China, and by 2010 represented the 90% of the turbines sold. The same positive remarks were identified in the solar panel sector, too, followed by more conservative progress, in the electric vehicles and energy-efficient lighting products.

The technological initiatives in electronics and green energy, the ongoing and increasing global future demand, and the economic crisis of 2008, which for a couple of years affected adversely the external demand levels, but also the increased domestic demand for rare earths have led China to reassess its rare earth policy. Furthermore, the absence of environmental regulation had become obvious in the level of environmental degradation exacerbating concerns over secure and stable access to domestic sources and transforming into priority the introduction of a new one.

By 2009, they were started the gradual restrictions in export quotas, encouraging the sales of finished rare earth products and limiting the export of semi-finished goods. Consequently, the threat of a possible increase of foreign dependence on China's finished goods was starting to raise.

In parallel, China attempted, unsuccessfully to gain the total international market advantage, by acquiring majority shares in international companies. Namely, China's effort to purchase Unocal/Molycorp under an extraordinary bid of $18.5 billion had swept U.S. governmental and business cycles raising a number of concerns on energy security issues as well as on China's investment and purchasing competences. The same policy was followed with two Australian companies that were involved in rare earths extraction (Lynas Corporation and Arafura Resources Ltd), ending in a blank space, too.[173] Nonetheless, the geo-economics tools of China were better applied in Africa, Peru and Chile, by establishing its economic influence through trade agreements and massive investment in mining abroad.[174]

The gradual increase in the level-price of REE was spiked after 2010 and the new restriction in export quotas. The redefinition of the Chinese REEs sector (the redesign of the Chinese domestic industry into three large districts (south-north and west), and the new standards both in mining licenses procedure and in environmental protection, and stockpiling endeavours) was done under the prospect *"to prevent over-exploitation, and blind competition, and to advance*

[173] Supra note 168.
[174] Barron, A., (2018*) Meet the new "renewable superpowers": nations that boss the material used for wind and solar*, (online) Available from: https://theconversation.com/meet-the-new-renewable-superpowers-nations-that-boss-the-materials-used-for-wind-and-solar-91680 (accessed: 10/06/2018).

the effective protection and scientific, rational use of these superior mineral resources", as the Ministry of Land and Resources has insisted.[175]

According to the Chinese authorities, the new policy was a remediation receipt in the context of sustainability and green development. According to the great importers, the restriction policy that followed the Chino-Japanese incident was an act that trigger the politicization of rare earth resources. The dependency on China became so obvious pushing states to the rapid identification of new policies.

Both the industrial and governmental sectors of the great importers of Chinese REE started to examine their alternatives. Despite that the high prices have increased the cost of importing resources, they have, also, boosted the investment interest in new projects for many states concerning the re-opening of closed mines or the construction and operating of new ones either domestically or in third countries.[176]

The re-opening of the Mountain Pass in California and Mount Weld, in an isolated region in south-west of Australia constituted the expanded list of alternative rare earth suppliers. The mines in Thor Lake and Koidas Lake, in Canada and the Steenkampskraal in South Africa offers great opportunities but, require time and enough capital to become operational. In parallel, a great number of researchers in the field of discovering new operational mines have been taken concerning a great number of states: Australia, Brazil, Canada, China, Finland, Greenland, India, Kyrgyzstan, Madagascar, Malawi, Mozambique, South Africa, Sweden, Tanzania, Turkey and Vietnam.

The new investment period brings a plethora of bilateral cooperation among advanced countries and developing states investing in new mines (Japan-Vietnam case). However, the challenge is not found, only, in the production stage, but, also, in the processing stage. China had managed to gather the complete control over all the exploitation stages of rare earths. Since the previous years, all the minor rare earth exporters had been sending their extracted amounts of REE to China for the implementation of the separation and the following processing procedures. Consequently, states should invest both in their upstream and downstream production procedures tin odder to achieve their full independence from China's industry.

[175] Supra note 168.
[176] Hurst, C., (2010) China's Rare Earth Elements Industry: What Can the West Learn? Institute for the Analysis of Global Security (IAGS); Smith Stegen, K., (2015) Heavy Rare Earths, permanent magnets, and renewable energies: An imminent crisis, Journal Energy Policy, 79, 1-8.

According to U.S. Geological Survey the mine production of 2018 was the followed: China 120,000tons, Australia 20,000tons, United States 15,000tons, Myanmar 5,000 tons, Russia 2,600tons, India 1,800tons, three countries share the same proportion: Brazil, Burundi and Thailand 1,000tons, Vietnam 400tons and Malaysia 200tons. From these data is confirmed once more again the dominating role of China in REEs market that is expected to retain for many years to come.

The big question is what will be the role of the new suppliers of rare earth in the global rare earth markets? Many of the states that possess rare earth resources are developing states that are overwhelmed by internal crisis, political instability, lax environmental regulations and weak GDPs. Are we moving cross to a new colonization era or is the chance for the new rare earth suppliers to follow the example of OPEC countries by establishing a new cartel that will maintain the equilibrium of the demand and supply function at an affordable and fair price?[177]

Without a doubt, developments around the rare earths industry are stormy, highlighting their multi-dimensional character. The need for the creation of a stable rare earth supply chain is the prerequisite in order to achieve energy and economic security. The transition into a new decarbonised and sustainable energy system is a challenge itself. The rare earths as critical elements in the new energy supply chain define the new geopolitics of energy opening a new chapter in the history of Energy Transition.

Table 2

World Mine Production and Reserves

	Mine production[e]		Reserves[9]
	2017	2018	
United States	—	15,000	1,400,000
Australia	19,000	20,000	[10]3,400,000
Brazil	1,700	1,000	22,000,000
Burma (Myanmar)	NA	5,000	NA
Burundi	—	1,000	NA
China	[11]105,000	[11]120,000	44,000,000
India	1,800	1,800	6,900,000
Malaysia	180	200	30,000
Russia	2,600	2,600	12,000,000
Thailand	1,300	1,000	NA
Vietnam	200	400	22,000,000
Other countries	—	—	4,400,000
World total (rounded)	132,000	170,000	120,000,000

Source: U.S. Geological Survey, Mineral Commodity Summaries, February 2019

[177] Supra note 175.

Conclusions

The challenge of Renewable Energy Sources as a leader to the New Energy Order lies in the new energy market under creation, as well as in the new geopolitical balances. In parallel, the international evolutions like the population augmentation; the ongoing electrification process that contribute to better life standards and a general prosperity that change the consumptions patterns; the climate change reality that push governments for more dynamic decarbonization policies; the ongoing economic and technology development, encourage the promotion of the New Energy Order.

As it has already been mentioned, the Energy Transition is a historically ongoing process that characterizes the human civilization and also signals the level of development of the technology used. Both in the past and in the present, it has been verified a different pace of integration of the energy transition among states and continents. The present categorization of states in five groups of general common characteristics helps the researcher to draw safer conclusions using comparable variables.

Although it has been recorded a promising increase in renewables since 2000, if we compare the 20-year development past-trend of other forms of energy in each ones peak periods we will find a typically low rate .[178] In particular, renewables share in the last 20-years period has been growing at an average annual rate of about 3%, whereas, coal between 1850-1870 had been recording an annual rate of 5%, oil during 1880-1900 an annual rate of 8% and finally natural gas had been recording an annual rate of 6% between 1920 -1940.[179]

By expanding the chronological framework for studying the diffusion of different forms of energy, a few trends that are more remarkable are identified. For instance, despite coal was recorded a stable rate of annual rate during 1850 -1870, it took 35 years to rise to 25% and 60 years to reach 59%. Just in the second decade of the 20th century, coal peaked at about 55% of the world's primary energy. The same pattern is identified both in oil and in natural gas shifts: *it took 40 years*

[178] OECD Data (online) Available from: https://data.oecd.org/energy/renewable-energy.htm#indicator-chart (accessed: 01/10/2019).
[179] Smil, V., (2016) Examining energy transitions: A dozen insights based on performance, Energy Research & Social Science 22, p.194-197.

for crude oil to range from 5% to 25% of world primary supply (1915-1955) and it has been almost 60 years for natural gas.[180]

In 2015, fossil fuels provided at least 85% of the world's total commercially primary energy supply. In 2017, investments in fossil fuels, as a share of total energy supply investment grew after 3 years of limited mobility.[181] To this end, the discovery of new reserves (pre-salt oil in Brazil, shale oil in U.S.) as well as the development of mining technology (horizontal fracking) have clearly contributed, giving a breath of optimism to the fossil fuel industry.

On the other side, the continuing falling costs of renewable technology offer an extra argument for the ongoing investment in innovation and clean technologies. One very promising sign of the successful course of the energy transition is that after 2015 even more petro-states (Saudi Arabia, United Arab Emirates) are investing in renewable energy projects. Their main motive is that they want their energy policies to keep pace with the energy transition and not to follow it, benefiting themselves from their renewable resources (sun and wind).

Despite years of efforts (since 1990s) to change the way energy is produced and consumed, substantial actions have taken place decades later. This is because we are a fossil fuel civilization and our way of life, from heating and cooling, to transportation and electrification, has been coherent with their use for many decades. The Paris Agreement and the commitment to a coordinated international action aiming in a decarbonized economy and addressing to the effects of climate change outlines the energy transition that is taking place.

A closer look to the new transition reveals a number of significant changes. The dominant use of renewables in electricity sector is gradually leading to the decentralization of energy system and the appearance of new actors, the prosumers, redefining from point zero the relationships between producer and consumers. This in turn creates new challenges and the need for a new regulatory framework. In addition, the exercise of power is shared at all levels (international-regional-national-subnational) reserving an upgraded role in cities, in line with high urbanization rates, increased energy demand and carbon emissions.

Since that energy stocks will be gradually displaced by energy flows, regional grids will replace the existed global markets. This will be a result of the upgraded role of electricity sector,

[180] Ibid.
[181] OECD/IEA (2018) World Energy Investment, (online) Available from: https://www.iea.org/wei2018/ (accessed: 20/09/2019).

transforming the whole world into an interconnected renewable grid. However, an integrated regional electricity system creates new challenges, difficulties and benefits that force the adoption of the appropriate regulatory framework in order to be ensured its smooth operation.

Natural resources had been for many years a key element in the geopolitical design of the international system. Renewable Energy Resources are coming to reassess the geopolitical map in the 21th century under new standards. According to a review, countries that dominate the export of rare earth minerals, which are proved indispensable in new clean technologies, will be the petro states of tomorrow. A parallel juxtaposition of the 1973 oil crisis and the 2010 rare earth crisis could confirm this argument. In 1973, the international community realized their independence in oil imports and the significance of diversity of resources in order to be energy secured. Later in 2010, after the Chinese policy of rare earths export restriction, the international community for one more time realized its dependency in REE imports, facing the danger of a supply risk. In both situations, the fear of depletion highlights the significance of resources in energy market and generally in the formation of geopolitical balances.

In the view of the new geopolitical rearrangements, due to the dominant position of renewables, and hence of rare earths, a number of critical questions arises as far as concerned the future international state balances. What will be the strong incentive for states to exploit the resources they possess? Would that be to participate in the supply chain, contributing in the security of supplies? Or, would it be better to accommodate an equal advantage against China, so as to put an end in the Chinese monopoly? Moreover, which factor will determine the balance of power between developed economies and developing countries rich of resources yet poor of economic and political stability? Finally, which will be the future for resource poor countries?

As long as the new technologies will continue to replace the old one and the renewables will dominate the energy sector, the demand for rare earths resources will continue to accelerate in a very rapid pace. Already, in the last decade numerous astonishing changes have being recorded. The study of rare earths is emerging as the number one topic in the academic community. The nations states have been considering different scenarios, which vary from the re-opening of the closed mines to the opening of new ones, as well as the exploitation of the seabed and deep ocean resources. In addition, in the context of sustainability the states have been examining the alternatives of substitutes and recycling methods in order to avert any unfortunate possibility of depletion of rare earth resources.

However, all the above alternative policies are expected to produce results over the medium to long term. In the short term, states with no or few rare earth resources should reassess the prospect of new partnerships with other smaller rare earth exporters, thereby creating a counterweight to the Chinese monopoly supremacy.

Additionally, the rare earth market is not like oil market. There is not a central institution of information on the production and trade patterns of rare earth, while illegal mining and smuggling raise further concern for the proper functioning of the market. The gradual liberalization of the market with the entrance of new players as well as the intensification of new forms of bilateral agreements (between states that are technologically and economically qualified and states that possess REE resources) could bring the balance in REE market creating a stable and secure environment for further investments.

The aforementioned analysis implies that the main challenge of renewables is lying in the type of the environment above which they will be established. Since 2010, and the increased concerns on security of supply, it seems that rare earths will replace fossil fuels as causes of tension and conflict, reaffirming one more time that the path to energy security will not be smooth enough. The new actors that are gradually arising in the rare earth market have to confront the monopoly supremacy of China. In parallel, new regions with large unexploited mineral reserves, such as the Arctic Region and the South China Sea will become the new strategic "chock points", redefining the geopolitical energy game.

To conclude, Energy Transition is inevitable to take place under conditions of zero tension and conflict. According to Goldthau and all, "*A zero-carbon world does not mean a zero-sum game but it produces different ones*".[182] Hence, the gradual formation of the new REE market should be grounded in the principles of fair competitions, security of supply and sustainability in order to eliminate any pathogens that have by far characterized the Chinese rare earth market as well as the energy market of fossil fuels.

[182] Goldthau, A., and all (2019) How the energy transition will reshape geopolitics. Springer, Nature, Vol.569, p.29-31.

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