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Logical Analysis on the Strategy for a Sustainable Transition of the World to Green Energy—2050. Smart Cities and Villages Coupled to Renewable Energy Sources with Low Carbon Footprint

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Abstract: This paper brings, as an element of novelty and originality, a strategic feasibility study, in the form of a logical analysis related to the proposed objective, with particularization to the area of the EFTA plus the UK and Ireland. We tried to achieve an overall picture of a sustainable and prudent transition at the macroeconomic level, but also at the microeconomic and local levels, with specific values of ecological and energy-smart villages/towns. The convergent actions of the signatory states of the climate treaty COP-26/2021—Glasgow, UK are to improve the logistics and financing of the large-scale replacement of fossil fuels used in the economy and lives of human society. Various strategies have been discussed to address the energy mixes that could be used in the transition phase in stages and combined-cycle natural-gas plants, conditioned by the implementation of CCUS technology. The preliminary stage will focus on the provision and implementation of modern technologies for the production of electricity in photovoltaic and wind power. Starting with the 2030s, the industrialized production of blue and green hydrogen is expected; the first is expected to be obtained from the chemical synthesis of natural gas with the separation and storage of residual carbon from chemical reactions, and the second directly from ocean water through the phenomenon of H_2O electrolysis. As a basic legislative element, the strategy aims to refine the idea of a carbon tax at the border or at the user, in order to discourage the use of fossil fuels.

Keywords: climate neutrality; fossil fuels; global warming; greenhouse gases; wind and solar photovoltaic energy; CCUS: carbon capture, use and storage

Citation: Chenic, A.Ș.; Cretu, A.I.; Burlacu, A.; Moroianu, N.; Vîrjan, D.; Huru, D.; Stanef-Puica, M.R.; Enachescu, V. Logical Analysis on the Strategy for a Sustainable Transition of the World to Green Energy—2050. Smart Cities and Villages Coupled to Renewable Energy Sources with Low Carbon Footprint. *Sustainability* **2022**, *14*, 8622. https://doi.org/10.3390/su14148622

Academic Editors: Pietro Bartocci, Gloria Pignatta, Adel Juaidi and Amir Vadiee

Received: 31 May 2022
Accepted: 6 July 2022
Published: 14 July 2022

1. Introduction

Throughout history, the use of energy by humankind has shifted to more concentrated, economically convenient, versatile, and flexible forms of extraction, transportation, and use. If the industrial revolution of the nineteenth century embraced coal with great enthusiasm, it set in motion the whole mechanism of industrialization, a series of other events, and human needs, in the first half of the twentieth century—both economically and militarily—in the value of the immense potential of oil, originally called black gold. It is a much more versatile fossil fuel than coal, even high-quality coal.

Both the massive development of the energy industry, with the widespread implementation of high-voltage alternating-current transmission and distribution systems, and the magnitude of the exponential growth of the industry—especially those strongly energy-intensive branches, but also of road and naval transport and air pollution—have led to the frantic use of refined petroleum products (petrol, diesel, kerosene, etc.). Of course, a major role in this supremacy of oil was generated by the two great world wars of the last century. To this, of course, is added the large area of residential consumption, of construction in general, which has actually "exploded", and which continues to rise as demographic evolution and the hospitality and entertainment industries demand it. In the last decades of the twentieth century, slowly but surely, natural gas and, later, liquefied natural gas became a fossil fuels, highly accepted by all of civilization and industry; it was seen, at the time, as a true refined fuel—elegant, clean, and, especially at that time, it was, of course, a huge step forward in avoiding the massive pollution that humankind had begun to feel and was trying to reduce. As a degree of pollution by combustion—more precisely, as a percentage of carbon dioxide released into the atmosphere—it was and is still half of coal or heavy liquid petroleum products, which also brings the disadvantage of releasing sulfur dioxide into the atmosphere.

However, of course, in the area of the energy industry—more precisely the production of electricity, certainly the largest consumer of fossil fuels—there are also non-fossil, extremely powerful alternative sources, such as nuclear energy and hydroelectric power. Undoubtedly, the potential to generate huge amounts of electricity is absolutely necessary for industry, transport and construction. Unfortunately, nuclear fission is a process that is as useful and efficient for the continuous generation of electricity as it is dangerous—in the sense that using fissionable radioactive elements poses a huge risk in both the use and the storage of radioactive waste from nuclear power plants.

If in the area of nuclear power plants, the application of a brake against their expansion in the future becomes a just reason. It is much more difficult to understand the braking policy applied, especially by the European Union to hydropower, because, in fact, we would give up a renewable source with high potential. It is true that ecological arguments are being made here that show the negative effect on aquatic biodiversity—much-amplified, however, compared to the critical energy situation we are in. On the other hand, the problem of noticeable emissions of carbon dioxide and methane from the related accumulation in lakes is quite serious, especially during the period of reduced hydrographic flows on the watercourses where these hydroelectric power plants are located. It seems that in addition to the well-known renewable sources at this time, we will have the ideal source, namely electricity obtained from non-polluting sources with its accumulation in the so-called green hydrogen, replacing the classic solution of electric batteries.

2. Materials and Methods

Politics is a significant driving force for the development of renewable energies (RE). Many studies have summarized the policies and development status of different countries. Scholars have applied empirical methods to analyze the influences of government policies on the development of RE. Boie classified government policies into production incentives and investment incentives [1]. He studied the driving effects of stimulus policies on the development of RE. Maslin and Scott [2] conducted several scenarios to predict the future development of RE on a global scale. They found that climate policies would impose constraints on the scale of RE development, and the magnitude of RE would also be influenced by technical changes in RE and the ability of RE to integrate with conventional energy systems. Chu and Majumdar demonstrated that government policy is the key factor driving RE development [3].

Zhou et al. found that government policy is important for the development of RE [4]. However, the effects of these policies vary significantly at different stages of the industrial development of RE. York considered that the development and promotion of RE technologies requires a long process [5].

Governments in all countries need to issue specific incentive policies for REs during this process. A solid understanding of policy-based ER development is needed to develop policies in the future. Clarifying the contribution of current policies to the development of RE is more important than assessing policy performance. Ding et al. gained insight into the mechanisms by which research and development (R&D) policies contribute to global photovoltaic (PV) development and discussed the issues caused by these R&D policies [6]. Based on this study, various research and development efforts should focus on improving photovoltaic technology, penetrating photovoltaic electricity, and system integration technology. Reducing political support could also have significant effects on the development of RE. Local government preferences are diversified in the process of developing RE, which leads to diversified policy needs [7–9]. Examples include the need for demand-driven policies to meet clean-energy requirements, investment-oriented policies to stimulate the development of related industries, and resource-oriented policies to promote the use of RE resources. A clear question arose: How should the central government formulate real-world policies in different areas?

Technical change has been recognized as a major driving force in the energy transition. Technological innovation in energy will be a key issue for national competitiveness. Building advanced energy systems that focus on providing clean energy is a major trend in shaping the world's energy transition. New energy systems should also transform energy consumption patterns [10].

The cost of technology is the key to widespread application and market success for RE [3]. Previous studies have focused on changes in the cost of RE technology and its influences [11,12]. Benson and Magee analyzed the rate of improvement of PV, wind turbines, and other low-carbon energy technologies [13]. Research by Gonçalves da Silva has shown that the development of RE is significantly limited by the intrinsic cost of energy and the way it is implemented [14].

There are exogenous environmental costs for all energy, including RE. Therefore, the development of RE must be comprehensively assessed in order to avoid significant damage to the environment [5]. Pillai developed perspectives on the factors that reduce the cost of RE technology based on technological cost, sales, and corporate capital investment [15–17].

Technological diffusion is the dissemination of information about new technologies or products caused by social learning [18–20]. Consumption of a new technology in the marketplace can raise public awareness of its value. This situation expands the potential demand for technology [21–23]. In reality, the application of RE technologies could take different forms. RE technologies are used in various fields, such as different RE power-generation stations [24,25]. These technologies are also applied in construction and agriculture. Such use of RE technologies is classified as a distributed RE application. Recently, the Chinese government has even used solar photovoltaics to reduce rural poverty [26]. In the field of RE technological development, Bollinger and Gillingham studied the influences of equal effects on PV diffusion [27].

Social acceptance also plays an important role in the dissemination of RE technology [28]. People's acceptance of RE technologies is affected by the characteristics of the technology (e.g., benefits and reliability) and the business environment; moreover, psychological, social, and institutional factors indicate that the key factors for the diffusion of RE technology include social recognition and acceptance of RE technologies, tolerance of technological innovation, and correct attitudes towards different technologies [1,29–32].

In terms of differences in technological development, resources, and the social environment, the diffusion of RE technology varies in different areas. Jacobsson and Lauber found, in research on wind turbines and PV diffusion in Germany, that RE diffusion rates differ between different regions [33]. The energy transition is now a major driver of ER development. In terms of demand, the energy transition and the development of ER call for a redesign of the current electricity market. RE technologies significantly change the production and demand of electricity [34].

3. Results

3.1. Elements Specific to the Concept of Elimination of Fossil Fuels from the Energy Mixture

Although it is not the first time in modern human history that the idea of phasing out fossil fuels has come up consistently and decisively, the beginning of the new millennium of the 21st century brings a completely different paradigm in this regard. Until now, the abandonment of fossil fuels and non-renewable energy sources has been seen, on the one hand, as a strategy to ensure energy independence for world economic and military superpowers; on the other hand, it has been seen as a strategy to perpetuate society, in the sense that sooner or later, these fuels will run out. Now, there is a completely different perspective. This seems to be becoming virtually irrelevant, which is essential given that greenhouse gas emissions from burning these fossil fuels will catastrophically affect human society and the entire habitat of the planet. The evidence in this regard is visible, unfortunately. The profoundly negative effects of this massive pollution involves the generation of the greenhouse effect, global warming and, implicitly, extreme climate change.

To meet the challenge of tackling climate change, we need to start by understanding the system of fossil fuels, namely, how energy is produced and used. Although fossil fuel companies are politically strong in the United States and around the world, their lobbying skills are not the main reason why their fuels dominate the global energy system. The reality is that both at the macroeconomic level and at the microeconomic level, change is perceived by all actors in the energy market as something practical against nature, although it is exactly on the side of nature. Additionally, switching to a fully renewable energy system is not a simple task from a technological and logistical point of view. On the contrary, it is seen by many people, more or less specialists in the field, as a real adventure, practically a crucial change in global society and, by far, the hardest challenge in the history of human civilization.

3.2. Europe's Transition to the Green Economy Compared to the Rest of the World

Although particularizing at the EU level, perhaps even at the European level (excluding Russia and the former non-EU Soviet states), optimism seems somewhat justified. Progress in benchmarking is essential for a successful transition. The World Economic Forum's energy transition index, which ranks 115 economies based on how well it balances security and access to energy with environmental sustainability and accessibility, shows that the biggest challenge facing the energy transition is the lack of training among the world's largest broadcasters, including the United States, China, India, and Russia. The 10 countries with the highest scores in terms of readiness represent only 2.6% of global annual emissions (Figure 1).

The world needs technology and strong policies to move in a new direction. Understanding the benefits of today's energy sources and the history of past transitions can help us understand how to move to low-carbon energy sources. With a better understanding of the climate challenge, we are taking huge steps in developing the technology we need to move towards a low-carbon future. However, understanding the process by which we arrived here and why the modern world was built on fossil fuels is crucial to understanding where we are going in the future, in perspective, until 2050, according to the estimates made by the International Energy Agency (IEA), in Figure 2.

In trying to understand where we are coming from in this crucial battle for the future of human society, it would be useful to look at the following diagram, in Figure 3.

Fossil fuels have allowed us not to rely on solar currents today, instead using concentrated solar energy stored for millions of years. Before we could use solar streams effectively, it seemed like a great idea. However, the benefits of fossil fuels come with a devastating disadvantage. We now understand that the release of carbon dioxide (CO_2) from the burning of fossil fuels is warming our planet faster than anything we have seen in the geological record. One of the biggest challenges facing humankind today is slowing down this warming before it changes our world beyond recognition.

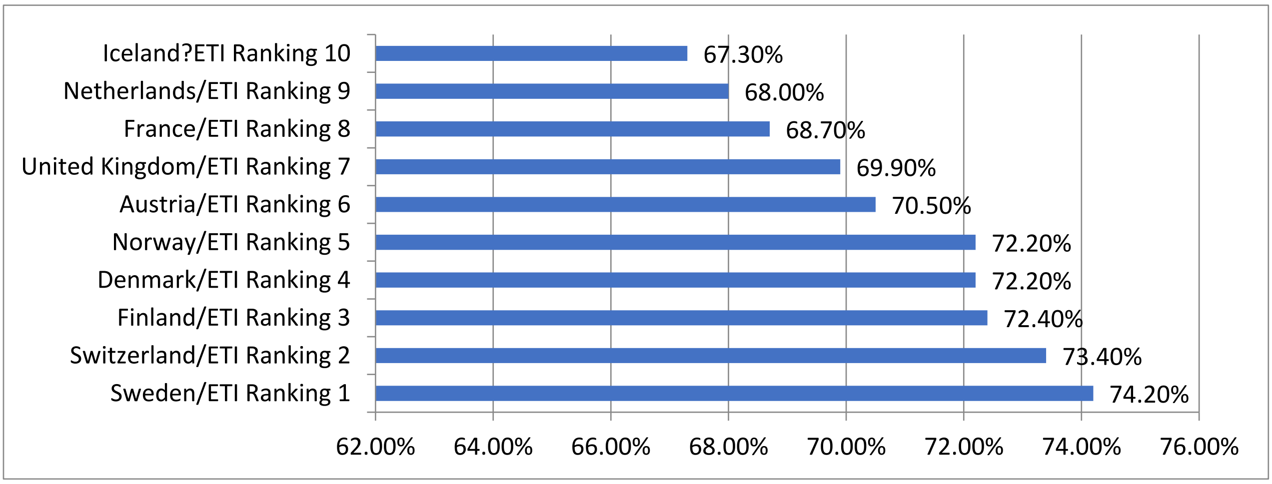

Figure 1. Top 10 countries most prepared for the energy transition. Source: World Economic Forum (WEF), Fostering Effective Energy Transition, 2020.

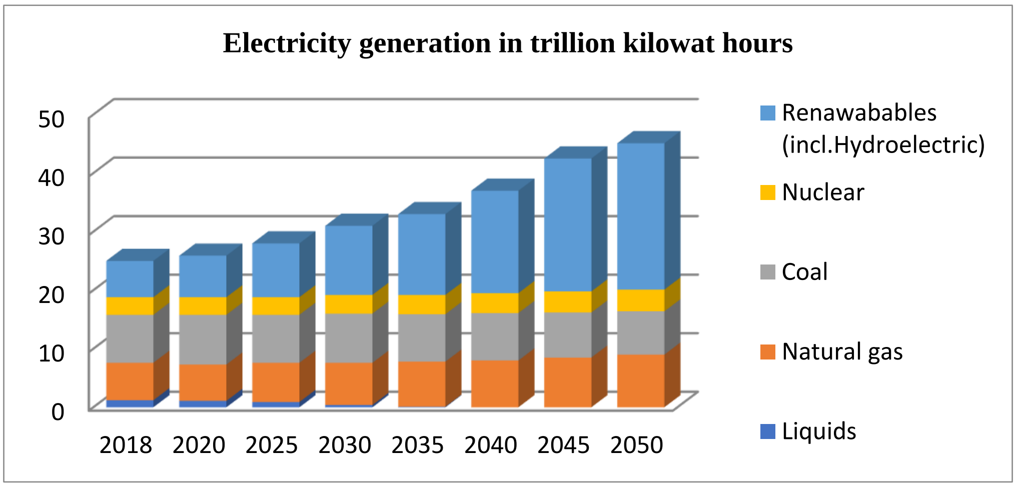

Figure 2. Worldwide projected electricity production by 2050. Source: estimates made by the International Energy Agency (IEA).

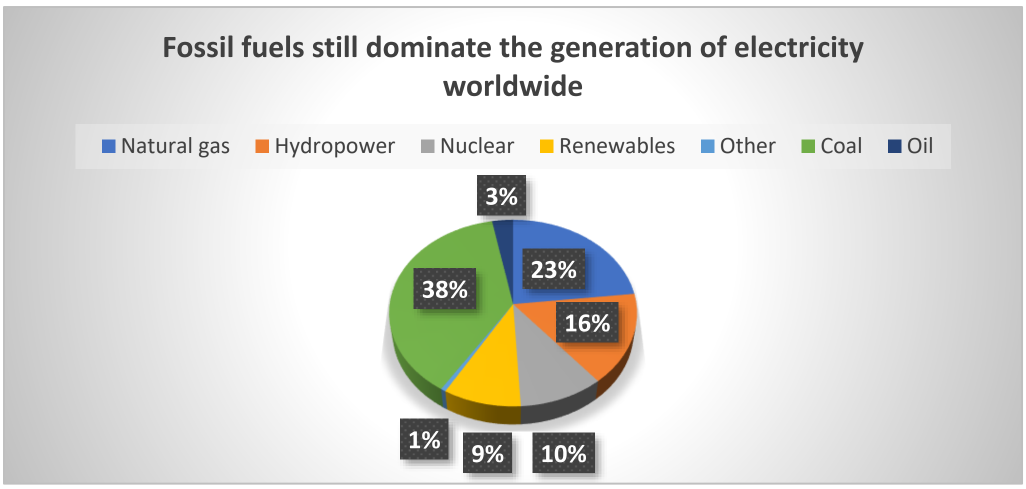

Figure 3. Fossil fuels still dominate the generation of electricity worldwide. Note: Data for 2018. "Other" includes sources not specified elsewhere, e.g., pumped hydropower plants, renewable waste, and statistical differences. Source: BP Statistical Review of World Energy 2019.

Now that the global population is almost eight billion, we can clearly see the impact of increasing CO_2 concentrations. Going back to the days when we relied heavily on biomass for our energy needs is clearly not a solution. However, we need to find a way to go back to relying on real-time solar and wind flows and energy from watercourses or sea waves (and maybe nuclear energy) to meet our needs.

There are many more of us now, interacting through a much larger and more integrated global economy and using much more energy. However, today, we also have technologies that are much more efficient than photosynthesis in transforming solar fluxes into useful energy.

3.3. Strategic Feasibility Study, in the Form of a Logical Analysis Related to the Net Zero Carbon 2050 Objective

Before any further comment on this subject, it is natural to ask: How true is the as-assertion that the accumulation of CO_2 in the Earth's atmosphere—as a result of the intensive, large-scale burning of fossil fuels in various states of aggregation—is the main reason why the greenhouse effect is constantly intensifying and, implicitly, why global warming, accompanied by visible and very intense climate change, threatens to become more and more frightening? Additionally, more than that, how physically and mathematically accurate are the global average temperature measurements available from 1880 to the present? Additionally, why is the margin of variation in the global average temperature so insignificant with an increase of 2 or, at maximum, 3 °C in relation to the year 1880, when the first recordings were made. Would this lead to an apocalypse?

Of course, in the scientific world of climatology there are clear and well-documented answers that show that all these assumptions are real, correct, and based on solid scientific support [35].

In fact, even if we ignore the huge influence of greenhouse gas emissions in the process of the imminent and disastrous climate change expected for this first century of the third millennium, it is absolutely natural to put ourselves in the position of replying to the question of the second half of the last century: How long will we have fossil resources, or at least those economically exploitable fossil resources? They are, of course, non-renewable. Additionally, this, in the context in which the demand for global energy will increase almost exponentially against the background of economic growth and technological developments, becomes more and more intense. Of course, this is in parallel with global demographic growth and the increase in the life expectancy of humanity.

However, at least as relevant is the question: How admissible, how risky, and especially, how strategically wrong would it be for economically developed countries to remain in the hands of the major OPEC fossil fuel exporters, or more recently, the extended OPEC Plus cartel?

Even if at first sight, in a global market economy, the prices of oil, or in a broader sense, of fossil fuels—as absolutely vital commodities at the moment—should be regulated automatically according to the principle of supply–demand balance, the reality shows us that things are much more complex when we equate two clear variables—namely, short-term profit and long-term, sustainable profit—in the future. Obviously any governmental or corporate entity could decide to take advantage of massive growth and desperation for energy demand of the global economy, not in the classical sense of increasing supply and, thus, turnover, but of deliberately falling below the value of demand, thus increasing unit transaction prices. In this way, it would maintain, or even increase, its immediate profit, while maintaining a reserve of fossil fuels that will allow it to make a sustainable profit in the long run; things are already becoming extremely alarming from an economic point of view.

Of course, in this sense, it is very likely that this great division of fossil energy potential, in distinct geopolitical/geostrategic areas, will soon lead to a military solution through extreme control of these energy reserves by one of the current superpowers—most probably the USA, but possibly also the emerging political conglomerate, namely Russia, China, India, and Iran, disguised diplomatically—by force of the current high-tech conventional weapons and/or the much-publicized hybrid war (by military, information, economic, and financial means), embargoes, and sanctions imposed, especially via the SWIFT mechanism, which is considered the "nuclear" weapon of financial transactions.

This is all the more pertinent as the Russian Federation—the second largest player on the oil market in the select world of the OPEC Plus cartel, and probably the first on the market of all fossil fuels (oil, natural gas, coal) of this organization—has become a huge strategic partner. If we add the fact that Russia has a major military force and, especially, a nuclear arsenal absolutely comparable to that of the United States, it becomes complicated.

It is probable that somewhere in the underground, the current large-scale military conflict related to the total invasion of Ukraine—in which the Russian Federation and NATO are indirectly but very deeply involved—could be based on other security and law enforcement considerations and this idea of control over the OPEC Plus area. At the same time, however, there is a serious potential danger of generating a large-scale geopolitical bloc between Russia, China, India, Iran and perhaps many other Asian, South American, or African OPEC states classified as anti-American states. In this configuration, the anti-Western geopolitical bloc would have huge advantages such as the energy reserves of this bloc, the economic power of China, and especially, the nuclear military power of the Russian Federation's anti-Western geopolitics.

On the other hand—in the pertinent version of the impossibility of generating an anti-Western political block—if we perform a simple exercise of imagination, in a scenario in which, in one way or another, the nuclear military power of the Russian Federation is annihilated by NATO, we will see a world in which there will be only one military, and especially nuclear, superpower, namely the USA. This means that the "Great Reset" would take on a clear outline, that of a single world government under the American flag. Of course, this exercise of imagination is extremely clear to all states in the world that hold the supremacy of energy reserves or are in full economic growth, but do not have a nuclear arsenal capable of counterbalancing the American arsenal.

However, OPEC Plus's resistance is likely to be extremely strong, well beyond the 1970s energy crisis. As is well known, in 1973, after the Yom Kippur War between Israel and a coalition of Arab countries, Middle Eastern oil producers declared an embargo on oil exports to the United States as a punishment for their support of Israel.

What followed was an energy crisis of epic proportions. According to **Daniel Yergin**, the **current energy crisis could be worse**, he writes on oilprice.com (accessed on 14 April 2022). The fact that today's deficit is all fossil fuels, not just oil, is one of the reasons why this crisis could be worse than in the 1970s, according to Yergin, who recently commented in an interview with Bloomberg. "I think this is potentially worse", the Bloomberg expert said. "It involves oil, gas and coal, and it involves two countries that happen to be nuclear superpowers [36]".

Another energy expert, David Blackmon, took a step further in the Energy Transition podcast, saying that the United States does not have the physical means to fulfill the promise that President Biden made to the EU to provide another 15 billion meters of LNG cubes. Blackmon noted the time needed to boost gas production and expand liquefaction capacity, as well as the limited LNG tank fleet and existing commitments to export LNG to other buyers.

In the Table 1, a series of centralized tables of values can highlight many truths about this geostrategic war between states with overdeveloped economies and those with abundant fossil energy resources.

Table 1. List of the top 15 countries in the world by Gross Domestic Product by 2020.

	Country/Territory	Region	IMF		United Nations		World Bank	
			Estimate	Year	Estimate	Year	Estimate	Year
1	USA	Americas	22,939,580	2021	20,893,746	2020	20,936,600	2020
2	China	Asia	16,662,979	2021	14,722,801	2020	14,722,731	2020
3	Japan	Asia	5,103,110	2021	5,075,759	2020	4,975,415	2020
4	Germany	Europe	4,230,172	2021	3,846,414	2020	3,806,060	2020
5	United Kingdom	Europe	3,108,416	2021	2,764,198	2020	2,707,744	2020
6	India	Asia	2,946,061	2021	2,664,749	2020	2,622,984	2020
7	France	Europe	2,940,428	2021	2,630,318	2020	2,603,004	2020
8	Italy	Europe	2,120,232	2021	1,888,709	2020	1,886,445	2020
9	Canada	Americas	2,015,983	2021	1,644,037	2020	1,643,408	2020
10	South Korea	Asia	1,823,852	2021	1,637,896	2020	1,630,525	2020
11	Russia	Europe	1,647,568	2021	1,483,498	2020	1,483,498	2020
12	Brazil	Americas	1,645,837	2021	1,444,733	2020	1,444,733	2020
13	Australia	Oceania	1,610,556	2021	1,423,473	2020	1,330,901	2020
14	Spain	Europe	1,439,958	2021	1,281,485	2020	1,281,199	2020
15	Mexico	Americas	1,285,518	2021	1,073,439	2020	1,076,163	2020

GDP (Million USD) per Country

Regarding this hierarchy, we notice that 10 of the first 15 places are occupied by states from the structure of the NATO transatlantic military bloc and alliance. These 10 states add up to a cumulative GDP of approximately USD 74 trillion, compared to only about USD 24 trillion, of the 5 states not included in the NATO bloc. However, such economic power and, implicitly, financial power, must be further supported by an appropriate energy base. Of the 10 highly developed NATO states, only the US–Canada binomial can claim a very serious energy base for the time being. However, in a few years of the states' own production of fossil fuels relative to available reserves, at this rate of extraction, there is a well-founded fear that the energy balance between production for the states' own consumption and export, on the one hand, and available land or sea underground reserves, on the other hand, will evolve in a totally unsustainable way. As for the oil reserves, another extremely suggestive list is presented in Table 2.

Table 2. List of the top 15 countries in the world by existing oil reserves in 2020.

	Country	US EIA	OPEC	BP	Others	Production	Years of Production in Reserve
1	Venezuela	303,806	302,809	300,900		831.1	366
2	Saudi Arabia	258,600	266,260	266,000		3818.1	68
3	Iran	208,600	208,600	155,600		1452.9	144
4	Canada	170,300	4.421	172,200	171,000	1336.8	127
5	Iraq	145,019	147,223	143,100		1624.8	89
6	Kuwait	101,500	104,000	104,000		1067.2	95
7	United Arab Emirates	97,800	98,630	98,630		1133.7	86
8	Russia	80,000	80,000	102,400		3851.3	21
9	Libya	48,363	74,363	78,400		366.1	132
10	USA	47,107	32,773	55,000	43,629	3239.7	15
11	Nigeria	36,890	37,453	37,100		730.0	51
12	Kazakhstan	30,000	30,000	30,000		582.2	52
13	China	26,022	25,627	18,500		1452.9	18
14	Qatar	25,244	25,244	25,244		555.9	45
15	Brazil	12,714	12,634	13,000	16,848	918.1	14

Going through these data, we can easily see that the oil reserves of the extremely economically developed states—with the first two places in the world, by far, being the USA and China—taken together, have values lower than some "pocket" countries, such as Kuwait, for example. According to data presented by the International Energy Agency, the US and China together have reserves of 73,129 million bbl compared to 101,500 million bbl in Kuwait, not to mention the comparison with Venuzuela—a reference country for poverty—which has a strategic reserve of approximately 303,806 million bbl.

Therefore, the figures show a huge, almost unbelievably large gap between the oil and gas needs of the world's major economies and their available reserves. Perhaps the most relevant message in this regard is found in the last column of the table, which estimates the years of production in reserve; it is calculated at the level of currently existing reserves, and is correlated with the level of production and imports. As presented, at this time, there were very large variations, both in the discovered oil reserves and in the level of domestic production and imports–exports. The figures indicate a period of 15–18 years, after which imports should fully cover the oil consumption of these large economies.

Additionally, this is in the conditions in which China and India widely use "dirty" coal for the production of electricity. Apart from this brief global analysis, we will return with an analysis at the European level—from which we will exclude Russia, Belarus, and Ukraine, second after Russia). These data, presented in Table 3, are quite dramatic, because in this area with a cumulative GDP close to that of the USA, oil reserves represent less than 0.5% of the global reserve.

Table 3. List of the top 15 countries in the world by oil production in 2020.

	Country	Oil Production 2020 (bbl/Day)	Oil Production per Capita 2017 (bbl/Day/Millions of People)
1	USA	11,307,560	35,922
2	Russia	9,865,495	73,292
3	Saudi Arabia (OPEC)	9,264,921	324,866
4	Canada	4,201,101	100,931
5	Iraq (OPEC)	4,102,311	119,664
6	China	3,888,989	2836
7	United Arab Emirates	3,138,249	335,103
8	Brazil	2,939,950	12,113
9	Iran (OPEC)	2,665,809	49,714
10	Kuwait (OPEC)	2,625,145	721,575
11	Nigeria (OPEC)	1,775,940	10752
12	Kazakhstan	1,756,705	88,686
13	Norway	1,712,937	313,661
14	Mexico	1,710,303	17,142
15	Qatar	1,530,000	500,000

In the current conditions in which the NATO embargo is progressively but very rapidly removing the Russian Federation from European oil production, we find that Europe (with the exception of Russia, Ukraine, and Belarus) is becoming a continent with negligible oil production, with only about 3,500,000 bbl/day; this is incomparable even with Africa—about 8,500,000 bbl/day—by far the poorest and most underdeveloped continent in the world (with Nigeria alone producing 1,776,000 bbl/day). Additionally, European oil production is well below Latin America at about 6,500,000 bbl/day, the second largest continent in the world, as an economic underdevelopment (note that here Brazil alone produces about 2,940,000 bbl/day, and Venezuela, the country with the largest oil reserves in the world, supports a drastic embargo imposed by the United States, through the UN, on oil exports).

On the other hand, North America is incomparably better in this respect compared to Europe. We observe that the USA, Canada, and Mexico have a cumulative production of about 17,219,000 bbl/day, i.e., about. 10 times higher, given that the cumulative GDP of the Europe area was at the level of 2019, at almost USD 20,000,000 million (very close to that of North America at about 2,350,000 million).

On the other hand, if—in the light of current geopolitical and geomilitary tendencies—we now add the oil production of the Russian Federation to the Asian continent, we notice that the production of this continent reaches approximately 48,635,000 bbl/day, so far from a figure that will bring this continent to an absolutely dominant position. Additionally, this is under conditions in which Iran—a strong OPEC force—supports American sanctions aimed at exporting oil. These figures, in view of the current embargo on oil exports to Europe, applied to the Russian Federation, lead us to the idea that the European continent will no longer have a leading position in the world in its fight towards the Net Zero Carbon 2050 goal.

It will probably be able to make up for the oil and gas shortage in the energy mix, only through the rapid reopening of coal mines and the urgent development of nuclear power plants. Of course, at the declarative level, the EU will attack the area of unconventional green energy extremely strongly. Unfortunately, this is only a matter of time for the future. Until then, Europe will face a devastating energy crisis and, thus, an economic crisis, with wind and photovoltaic production currently the most viable non-polluting renewable energy resources.

Moreover, in these moments of maximum geopolitical and geomilitary payload, with risks almost unprecedented in history, governments—especially the vast majority of European ones—will enter into a large-scale conflict with both the population and, to a lesser extent, large corporations and domestic or international companies—with major energy deficits in the absence of oil and especially Russian gas—and will be in great difficulty. Looking at the Table 4, we ask the pertinent and perfectly justified question: Given the US imposing an increasingly drastic embargo on the Russian Federation's oil, gas, and coal exports to the EU27 and European NATO member states, how could the European Union compensate for the need for fossil fuels (eliminating Russia and OPEC countries from overseas and oceans—countries that do not support increasing production)?

Table 4. List of the top 15 countries in the world after oil exports in 2020.

	Country/Region	Oil Exports (Bbl/Day)	Date of Information
1	Saudi Arabia (OPEC)	6,658,642	2020
2	Russia	4,653,500	2020
3	Iraq (OPEC)	3,428,379	2020
4	Canada	3,037,668	2020
5	Iran (OPEC)	2,700,000	2021
6	United Arab Emirates	2,418,388	2020
7	Nigeria (OPEC)	1,879,288	2020
8	Kuwait (OPEC)	1,826,331	2020
9	Norway	1,501,768	2020
10	Kazakhstan	1,410,917	2019
11	Angola (OPEC)	1,219,656	2020
12	Mexico	1,198,511	2020
13	Oman	859,883	2020
14	USA	850,000	2020
15	Brazil	832,473	2016

Of course, there is still a small lifeline: Norway, the only European country with a massive surplus of oil and gas. However, in addition to the fact that it can only compensate for a small part of Russian gas and oil, we should think that the largest producers of oil and natural gas in Western Europe, namely Norway and the UK, are not part of the EU. We know that Norway has long been directing its European oil exports to the North Sea to the UK and Sweden–Denmark, leaving most of Europe in the area of influence of the Russian Federation, i.e., in the dark, perhaps not only figuratively, but literally.

Therefore, as a final conclusion, the goal of progressive, constant, and safe elimination of conventional/fossil energy sources at the expense of renewable and/or non-polluting sources becomes a goal as relevant as it is necessary in the next stages of the development of human society. Additionally, as many have said before the invasion of Ukraine by the Russian Federation, this desideratum would be the greatest challenge to human society in history—according to the perspective estimates.

3.4. The Major Risks, Challenges, and Disensions between the States of the World Related to This Global Energy Crusade

As is widely recognized at this time, the evolution of the global economy on the same parameters of energy consumption—with the predominance of the use of fossil fuels in energy, industry, transport, construction and other essential human activities—will lead us, by 2050, to an increase in average temperature of a minimum of 2 degrees Celsius compared to the reference year 1880, i.e., higher than the maximum limit allowed by climatologists (1.5 degrees Celsius). By the end of this century, without radical changes in the configuration and structure of primary energy sources globally, temperature rises would be at least 3 °C. Worse is the fact that this growth is only an average, the peaks of growth being recorded at the poles of the planet, where the growth can reach up to 8 °C.; this would involve a virtually complete melting of glaciers and, thus, a massive increase in the water levels of the planet's oceans.

First of all, it is worth noting and emphasizing the well-known fact that, until recently, the following slogan was used very frequently: "Let us unite all our efforts and forces to save our wonderful planet". No, the real problem is to save ourselves as human beings, as the human species, and probably a multitude of terrestrial and marine habitats that shelter animal and plant life. The planet, in the event of such a cataclysm, will certainly be restored in a very short time on a geological scale.

Even if this vision can be more-or-less exaggerated in relation to a future reality that we certainly do not know, but only intuit through the evolutions of the last 150 years, it is certainly a serious threat; it could be even worse and faster than we can predict at the moment if, as is the case at this time, other strong threats emerge, such as global military conflicts, or even just hyperinflation and intense economic crises globally.

Such developments would severely affect the ability of economies and finance to sustain a huge investment effort into industrial, technological, and comprehensive research for the large-scale development and implementation of high-performance equipment and installations for the world's new energy industry.

First of all, this question is asked correctly only in the following way: Will all the states of the world unite globally, with all the interest and all the determination, and what action, exactly, will they undertake? Will they unite regardless of the underground, terrestrial, aquatic, and marine reserves they have, regardless of the stage of economic development in which they are, and regardless of the political regime or the cultural–religious specificity? We are talking about an extremely serious planetary problem, not a local, national, federal, community or continental issue. However, under these geopolitical conditions, unity of action will become virtually impossible.

It is difficult to understand, and obviously, very difficult to admit, that geopolitical areas based on high technological development, and implicitly economic since 1880 (considered in all comparative analyses of global climate change as a reference year)—for example, the NATO Block, Western Europe, parts of the Russian Federation, and even those who have, so far, fully consumed fossil resources to be abandoned in the near future—will be able to reach a common denominator in this regard with the new economic powers, or even emerging economic powers, in the full economic expansion of Brazil, India, Mexico, and—ranked highest, by far—China.

Additionally, it is very difficult to admit—despite the obvious climatic realities—that a geopolitical area of great energy power and that is implicitly political—such as the OPEC Plus cartel, including the Russian Federation—will resignedly and even contentedly witness the loss of their hegemony of the oil and gas industry, implicitly of the constant profits that are really vital for the economy and the quality of life of their population—which they obtain from the large-scale extraction and export of fossil fuels.

Moreover, if this were to happen at some point during this half-century, geopolitical areas of power could suffer a high-magnitude "tectonic" movement. Other areas of the US and, to a lesser extent, Western Europe have the majority of control over fossil energy resources in the OPEC Plus area, with the notable exception of the Russian Federation mentioned, to accelerate the implementation of green energy—to the detriment of abundant fossil fuels destined for export—under the pertinent pretext of the sufficiency of green energy for their own economies and populations.

Last, but not least, we must admit that such a far-reaching political decision would be taken within a global intergovernmental organization, namely the United Nations; without the approval of the private sector, state/government ownership, the concession of oil and gas fields, extraction, transportation through pipeline systems, and often, even their refining are in the hands of multinational private corporations.

Alternatively, there would be a terrible dispute between the established democratic principles of the market economy and the policy of strict regulation of governments that should be established in this regard. In other words, these private superpowers that have made huge investments on their own should accept the functioning and development imposed by national and/or international government forces.

More precisely, these companies should largely reinvest their profits in the drastic change in the object of activity, progressively moving from the sphere of extraction, transport, and refining of oil and gas to that of green energy production.

Undoubtedly, we cannot rely on a unanimous opinion and implicitly on actions in this regard. Additionally, we are not talking about stubbornness, energy-economic rigidity, or simply a totally different approach generated by corporate or governmental pride. However, there are, first of all, basic laws and contradictory interests between the logic of the functioning of a private corporation and that of a governmental entity, which are evolved and highly representative. Another element of substance is the fact that there are, indeed, many states in the world, some even extremely well developed economically, but which are practically unprepared for a change in this regard, as fast as it is radical. The amendment would bring incalculable damage to the proposed economic growth and, implicitly, to stability on all levels: economic, financial, political, social, and last, but not least, in terms of armed national security.

Therefore, we are dealing with a move that is as necessary as it is risky and dangerous. The ideal of climate neutrality Net Zero Carbon 2050 may seem distant in time, but compared to the stage we are starting at this time—namely that about 80% of the global energy mix is represented by fossil fuels—about 15% of hydroelectric and nuclear energy and an optimistic maximum of 5% of new renewable sources, such as biofuels, wind and solar, make it clear that the time allotted is extremely short.

Of course, the first correct idea in this regard has already been issued, namely, rewards for states with the potential to absorb carbon atmospheric net-ecological states and, respectively, sanctions for states with the potential to emit carbon atmospheric net-polluting states.

However, as this carbon tax was originally intended, it applies to the border of the exporting state of goods, products, or utilities for the production of which large quantities of fossil fuels have been used—entered directly or indirectly in the production process. A charging strategy would be profoundly wrong because there are at least two major ways to avoid charging.

The first would be obvious, by increasing imports of goods, products, utilities, etc. to massively reduce the balance of carbon emissions in that state, when it has the economic and implicit financial strength to resort to massive imports from other states. The second, perhaps even too-often used already, is the outsourcing of the production of products, material goods, energy, or even fuels/fuels with high carbon content (more precisely, carbon dioxide) from the base country to a tetra country, usually with an emerging or even underdeveloped economy.

From this point of view, at the moment, the so-called end-user fee is carefully analyzed. Of course, in both cases, a correct methodology that is easily applicable and, especially, almost unanimously accepted, will be a great challenge; it will probably be reached in a truly optimal form only after a series of successive iterations imposed by the various situations in the experience gained by the third-party contractors [37].

Legislating the regulation of greenhouse gas emissions will certainly be much more difficult than it seems at the moment. For example, China has announced a comprehensive carbon tax program, based on a strategy very similar to the automotive industry—with super-mediated pollution taxes, some even grossly counterfeit—but which, in principle, pursued an incorrect goal, namely to reduce specific CO_2 emissions to 100/km traveled in standard conditions. This was implemented without any clear goal of reducing absolute emissions, which is very interesting. More cars, more power, but specific emissions "much diminished"!

On the other hand, in order to effectively determine and drive any state in the world to sincerely and strongly adhere to this unprecedented changing energy revolution that involves high costs and sacrifices to the economy and quality of life in that state, there must be international financing of the vast global process. The transition to green energy should be designed so that participation is commensurate with the estimated value of fossil fuel consumption for economic and military purposes from the reference year 1880 to the present.

Of course, it is quite difficult and sometimes deeply subjective to estimate how much each state has "erred" in this nearly 150-year period, all the more so as the geopolitical map has changed after two world wars and many other regional wars from then until now.

This is made all the more difficult, as it should be taken into account whether and how much each of these states has contributed to global ecological degradation through the deforestation of forests and terrestrial or marine vegetation; by terrestrial, aquatic or marine pollution; and by any other activities generating greenhouse gases—a relevant example being the livestock sector and part of the agricultural sector.

For an overview of the share of the main economic sectors in greenhouse gas emissions—CO_2 equivalent, a circular diagram of them is presented Figure 4, globally, for 2016. We can assume, quite correctly, that the current percentage weights are maintained in the immediate future, close to those presented in this source.

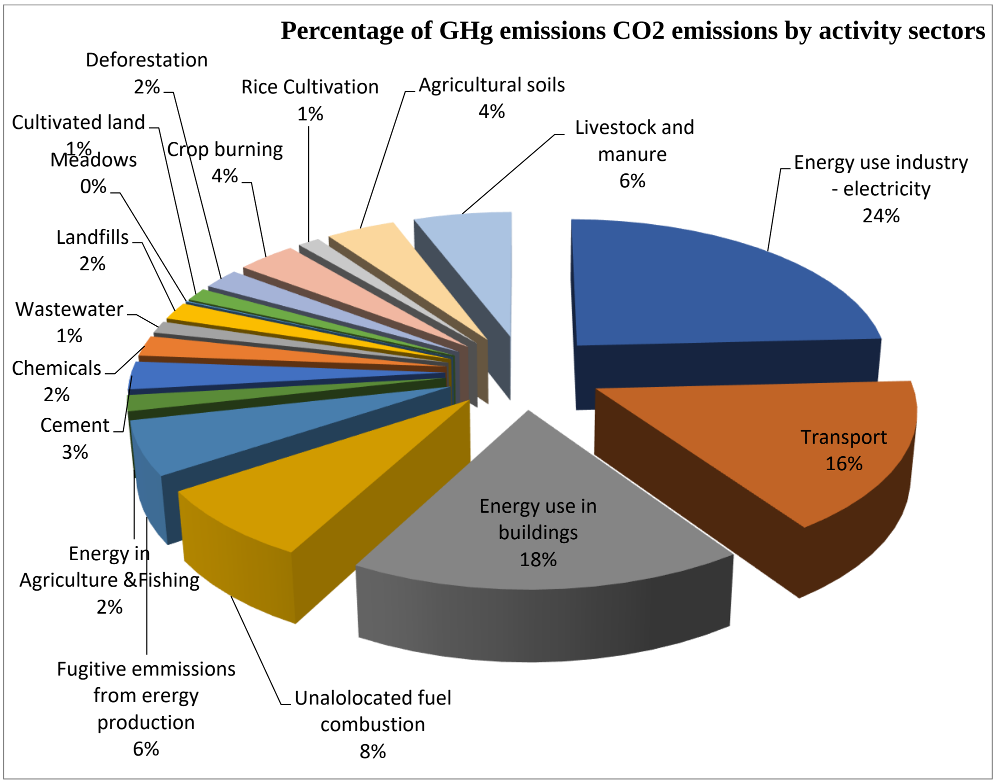

Figure 4. Global greenhouse gas emission by sector (2016). Source: Climate Watch, the Word Resources Institute (2020). OurWorldinData.org—Research and data to make progress against the world's largest problem.

Emissions come from many sectors; we need many solutions to decarbonize the economy. It is clear from this breakdown that a multitude of sectors and processes contribute to global emissions.

This means that there is no one-size-fits-all solution to tackling climate change. Focusing on electricity, transport, food, or deforestation is still insufficient. Even in the energy sector—which accounts for almost three-quarters of emissions—there is no simple solution.

Even if we could fully decarbonize our electricity supply, we should also electrify all heating and road transport. Additionally, we still have emissions from shipping and aviation—for which we do not yet have low-carbon technologies—to deal with.

From the presented results, the fact that although, at first sight, all the emissions and all the dangers derived from greenhouse gas emissions are generated from energy, industrial, technological, and transport processes, and from ensuring the microclimate of civil and industrial constructions, a series of factors that are quite important from GHG emissions are due to other human activities or even natural processes, such as forest fires, soil degradation, deforestation, or any other process aimed at CO_2 storage capacity.

3.5. What Would Be the Solutions and Strategies for the Massive Implementation of Green Renewable Sources at the Planetary Level, So That by 2050, the World Will Achieve the Goal of Net Zero Carbon?

It should be noted here that net zero carbon does not mean zero carbon emitted/released into the atmosphere, but the fact that the algebraic sum between technological carbon emissions, on the one hand, and the natural and/or artificial capacity for capture and storage, on the other hand, be less than or equal to ZERO [38].

Most likely, a super-optimistic and strong approach—which involves giving up super-polluting fossil fuels (coal and petroleum products) or semi-polluting fuels (natural gas) and nuclear energy, or even in the case of EU hydropower, which, although non-emitting, is not considered an ideal source in the energy mix, implying a multitude of risky/dangerous aspects in operation for humans and/or nature/habitats. This is because our world constantly needs a high level of energy to function in conditions of sustainability and economic growth, corresponding to population growth and average life expectancy. Our planet must maintain the internal energy of rotation around its own axis, with a constant speed. In fact, we are living witnesses of this, which means a substantial reduction in the level of global energy consumption—see the world situation in the first half of 2020, when the coronavirus pandemic froze much of the economy and social life.

Alternatively, if we set out to fully assimilate the ideas presented and disseminated at the last NATO summit on climate change in Glasgow, human society should give up coal and oil products altogether, at least in the area of the energy industry. We should also give up a lot of natural gas, both in the energy industry and in the area of civil and industrial construction in terms of heating and/or air conditioning. Even if it is not very clear and decisive from COP 26′s exposition, we should practically freeze at least the development of hydroelectric and nuclear power plants.

In addition, we should freeze the new investments in the oil and gas industry, as clearly stated by the International Energy Agency, in its strategy of energy evolution towards Carbon Zero.

In this idea, in the first stage, in the happiest case, it would be acceptable and possible to give up coal and heavy liquid hydrocarbons in the area of electricity production only, and only if it would be possible, to a small extent, to use natural gas; instead, the area of hydro- and nuclear-production should be seriously amplified.

Unfortunately, at the moment, the extremely violent conflict between NATO and the Russian Federation—which, fortunately, is still non-military—will give back this perspective of action towards the goal of decarbonizing energy. Additionally, this is not because interest in this would diminish, especially for Europe and North America, the main promoters of this energy policy. On the contrary, the goal of escaping energy dependence on the Russian Federation would be a huge boost in promoting the ultra-fast and widespread removal of fossil fuels from the energy mix, to the detriment of clean renewable sources.

However, unfortunately, in this economic war of sanctions and embargoes, Russia's economic downturn will undoubtedly weaken the economic and financial support of this energy revolution, not to mention the possible escalation of conventional and, perhaps, even nuclear war worldwide.

In fact, a nuclear war between the United States and the Russian Federation, without the involvement of the rest of the world, would be more than enough to close any discussion on this energy revolution.

However, let us ignore this possible bleak scenario in the future; wind, photovoltaic equipment, and maybe electrolyzers for green hydrogen fuel production, as well as unconventional, renewable, and non-polluting sources will be massively introduced.

It is only in the second stage, probably after 2030–2035, that natural gas could be almost completely abandoned, given that it will amplify, or at least maintain, the pace of development of nuclear and hydroelectric power plants; moreover, it will aggressively address all high-tech sources and equipment in the field of onshore or offshore wind energy with or without green hydrogen via electrolysis of water, photovoltaic or hybrid solar energy, terrestrial or ocean biofuels, and low-pollution waste by combustion. It is important to note that natural gas has a number of essential advantages, so it is difficult, even very difficult, to give up power plants, surpassing even fissionable radioactive nuclear fuel. In other words, a power plant that operates natural gas—especially in the combined cycle with steam and gas turbines—having, for example, an installed capacity of 1000 MW, with all the equipment, primary and auxiliary constructions, warehouses and any other necessary utilities—will occupy the smallest area compared to any other similar power plant, using any other known energy resource. In addition, it is the most common and efficient raw material for the production of industrial hydrogen, and about 50% of coal is the least polluting and most versatile common fossil fuel. This is, of course, the case today; surface area would become much smaller, in addition to flue gas treatment equipment and underground storage of carbon dioxide or solid carbon resulting from the combustion and processing of flue gases.

In the final phase until 2050, probably in parallel with the widespread promotion of photovoltaic and wind solar sources in onshore or offshore parks—which, in the meantime, will probably develop exponentially in terms of energy efficiency, reliability and especially financial efficiency—a number of high-performance technologies in the area of using green hydrogen as the base fuel of the future can be addressed, such as hydrogen–oxygen fuel cells; these would be extremely talked about, or perhaps more sincerely criticized as energy and even in terms of economic efficiency.

In conclusion, we believe that the so-called key to the global implementation of green energy will have to be based on pragmatism and political and strategic wisdom, correlated with massive funding of the research and development area in the energy and technology field. Wise time-planning will obviously always involve risks—directly referring to the danger posed by the widespread use of nuclear and even hydropower which, in excess, will profoundly damage plant biodiversity and animals of rivers and streams. If we want everything quickly, perfectly, and surely, it would be very possible to find that instead of saving the planet and human society, we will reach economic and social self-destruction with gigantic steps.

This is because if the steps we take are wrong, we will soon be facing a huge imbalance between the supply and demand of electricity and fuel—that is, the basis of the entire world economy, the rapid and severe collapse of the entire global economy and, thus, a rampant hyperinflation; these are far too difficult to imagine at this time, although we already feel the bitter and toxic taste of the economic crisis generated by the direct Russia–Ukraine conflict, and especially the indirect one between NATO and the Russian Federation.

Moreover, we must take into account, and be very attentive and flexible to, the so-called change in variables, which can always be generated by the complexity of natural factors, and perhaps even more so by artificial ones created by the complexity of human society at this moment due to a series of geopolitical and geostrategic aspects; at some point, these may force us to choose the least evil, even if this choice would be in total contradiction with the previously proposed objective. For example, there is more and more talk—especially at the European level—about the emergency and forced reactivation of coal mines, considered to be, by far, the most polluting fossil fuel intended for the production of electricity and/or heat.

As an economic/energy response to the reduction in European gas imports from Russia, the US has induced, for Europe, the prospect of replacing Russian gas with liquefied natural gas from its own production and that of Qatar; these two entities are currently the world's largest players in the LNG market. However, on the one hand, Europe's infrastructure is not well adapted to this change, which involves unloading gas from special LNG carriers, storing it after unloading, regasifying it by returning the GN to the gas phase, and introducing it into the classic GN pipelines. However, all these operations increase the price of gas in the final form distributed to large industrial and/or residential consumers. In Australia, it is not known how long the traditional customers of this market will suffer. This effort can be sustained if the war in Ukraine lasts. However, it depends on how long the Russian Federation's trade in energy export sanctions will be maintained.

However, although it is difficult and very frustrating to accept and recognize, Europe is, and will probably remain, open for quite some time in terms of energy and, in general, in terms of the supply of raw materials for industry and food. Because the embargo on Russia will add to the difficulties of Ukraine—which has also been a major player in this European market applied to Russia, frantically supported by the EU—increasingly broad and severe, will it not have a terrible boomerang effect on Europe rather than Russia itself?

For now, the crisis is felt to be serious, even very serious, but still unbearable and unacceptable, because many European countries still import massive amounts of gas and oil from Russia, and perhaps other industrial or food raw materials. However, as the circle of compromises will tighten and time will pass, many European countries, some even NATO members, will no longer have the strength and tools needed to make up for this large trade imbalance.

3.6. Scientific Aspects and Relevant Explanations Regarding the Extremely Powerful Effect That Greenhouse Gases Have on the Temperature of the Planet

The key to the strong influence of carbon dioxide on the climate is its ability to absorb the heat emitted by the surface of our planet, preventing it from escaping into space. Carbon dioxide, as well as other greenhouse gases, were detected and highlighted via laboratory experiments by two pioneers of earth physics, Eunice Foote (1856) and John Tindall (1859). It was almost astonishing to find that diatomic gases, such as H_2, O_2, and N_2, do not have this ability to retain radiative heat. Their experiments also looked at the evolution of the CO_2 concentration in the Earth's atmosphere, according to the Figure 5 below.

If we use a common analogy, it should come as no surprise that a small amount of carbon dioxide in the atmosphere can have a large effect. For example, when we take medication, it will represent a tiny part of our body mass, but the effect is sometimes strong. Today, the level of carbon dioxide is higher than at any time in human history. Scientists strongly agree that the average temperature of the Earth's surface has already risen by about 1 °C since the 1880s, and that human-made increases in carbon dioxide and other heat-absorbing gases are highly likely to be responsible.

Without emission control, carbon dioxide could reach 0.10% of the atmosphere by 2100, more than three times the level before the Industrial Revolution. This would be a faster change than the transitions of the Earth in the past, which had huge consequences. Without action, this low concentration of greenhouse gases—CO_2 or equivalent to CO_2—in Earth's atmosphere will cause great problems for life on Earth.

In is important to look at and analyze, with relevance, the valences revealed with utmost clarity by the new geopolitical and geostrategic developments vis à vis the primary goal of the rapid transition to green energy—especially for the European economic space outside the Russian Federation and quasi-politically influenced areas.

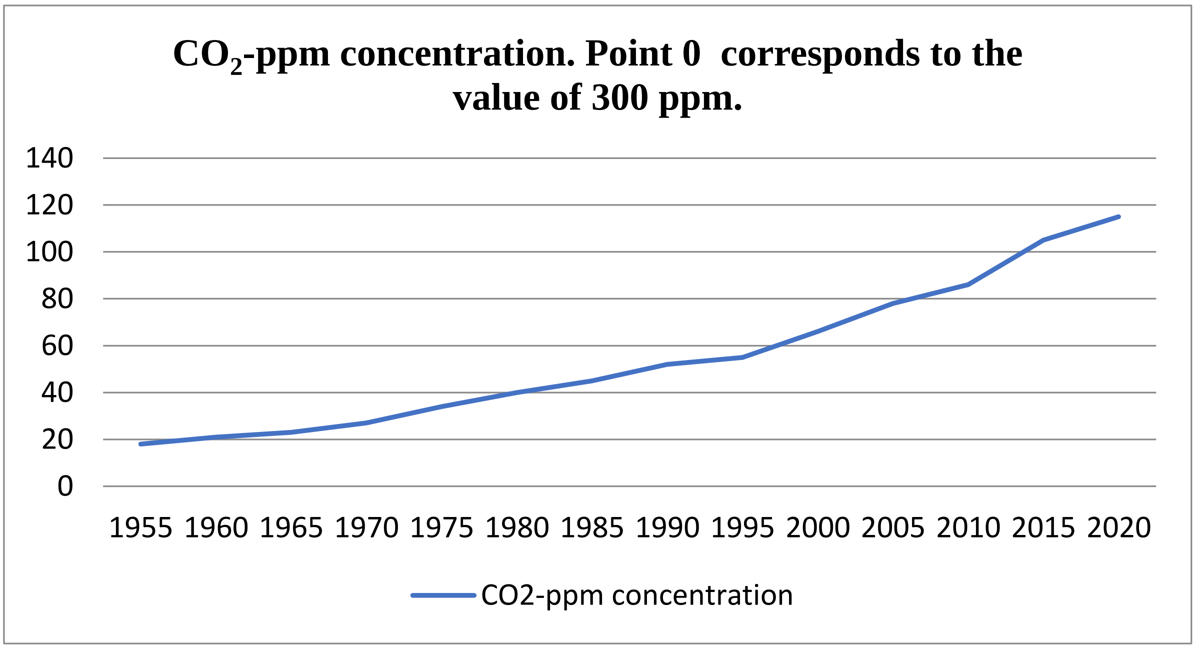

Figure 5. Carbon dioxide concentration at Mauna Loa Observatory. Source: Latest CO_2 reading, 8 September 2019; the "Keeling Curve", named after scientist Charles David Keeling, is the accumulation of carbon dioxide in the Earth's atmosphere, measured in parts per million. Scripps Institution of Oceanography.

Looking at the proposed goal from this angle, we easily notice that the transition to unconventional or relatively non-polluting sources is a much bigger urgency than we would have anticipated before 2022. Additionally, for an extremely simple and important reason, the rupture of Europe's huge dependence on Russian gas and oil is extremely visible—especially gas, leading to the desperate action of Russian-speaking economic "de-fossilization". With the irreversible phenomenon of climate change caused by the greenhouse effect, Europe will largely face the difficulty of putting the coal supply chain back into operation in the economy.

The goal of "sending coal into history" was a key goal for the UK, as the host of the COP26 summit, which aims to put the world on the right track to limit global warming to 1.5 °C above pre-industrial temperatures. Expert assessments have found that in order for the world to remain within 1.5 °C, developed economies should phase out coal by 2030, rather than in the 2030s, as agreed in the agreement. However, we now ask ourselves, in the geopolitical context that appeared at the beginning of 2022, at what price? Or rather, will we destroy the European economy immediately and quickly from a medium-term perspective by abruptly giving up this coal? Additionally, not even trying to replace it with intensive hydropower, or somewhere based on wind and photovoltaic energy, we will enter an area of absurdity at this point.

Additionally, not only does Russia confuse us a lot in this desideratum, but also, the huge dependence on the OPEC countries—which, practically, we cannot force to modify their energy investment policies, and especially the conservation of their underground resources, in order to solve the current energy crisis—is amplified by NATO's position on the Russian Federation's energy exports.

Effective and synthesized at this time—the year 2022—the world in general, and the democratic world in particular, is facing perhaps the worst danger so far in history, namely, a multiple economic, financial, energy and food crisis—while considering the sanitary pandemic crisis. Towards the end, though, there were still serious signals coming from China. The vast majority of military analysts treat the idea as a last-minute propaganda ploy by the Russian Federation—similar to the 1962 Cuban Missile Crisis; note that at that time, the withdrawal of the Russian nuclear threat was negotiated by John Kennedy and Nikita

Khrushchev—then-presidents of the United States and the USSR, respectively—through the gradual and tacit withdrawal of US nuclear warheads from Turkey and the commitment of Cuba's inviolability to the United States.

However, at some point, a contest of unfortunate and uncontrollable circumstances or those incorrectly controlled by one of the parties—Russia or NATO—makes us digest, with great difficulty, this unprecedented policy of extremely aggressive sanctions and accusations of President Joe Biden towards the Russian Federation; these are clearly directed at Vladimir Putin, a man called a "war criminal" from whom you can expect any kind of uncontrolled reaction, and personal and/or national pride.

Under these circumstances, the enthusiasm and commitment of the nations of the world—especially the EU and the UK, which, at the Glasgow Conference, seemed determined to embark on the ideal of climate neutrality, Net Zero Carbon 2050—is changing; optimistically, we are dismissing the global nuclear conflict, or even just the conventional Russia–NATO conflict.

4. Discussion

As mentioned earlier, the mitigation of inherent climate change means, firstly, the reduction in greenhouse gas emissions—measured in tones of CO_2 equivalent—to the point where emissions become, at most, equal to their absorption by terrestrial and marine/oceanic vegetation, which, in turn, consumes carbon dioxide in the biochemical process of photosynthesis. As about 80% of these GHG emissions come from the energy sector, industry, transport, and the cold chain for the food industry, the problem of phasing out fossil fuels, therefore, arises. For the rest of the GHG emissions of approximately a 20%, reduction measures are not related to the use of fossil fuels [39].

According to the latest estimates of the International Energy Agency in 2020, the global energy mix remains focused on fossil fuels for the entire period analyzed between 1996 and 2020. Although there is a clear increase in the share of new renewable resources and hydroelectric power, this does not look spectacular, especially as the global need for electricity has increased; additionally, the Figure 6 shows the variation in the percentage weight of the energy produced on the same sources or fuel highlights a still very modest contribution of renewable resources in the global energy mix.

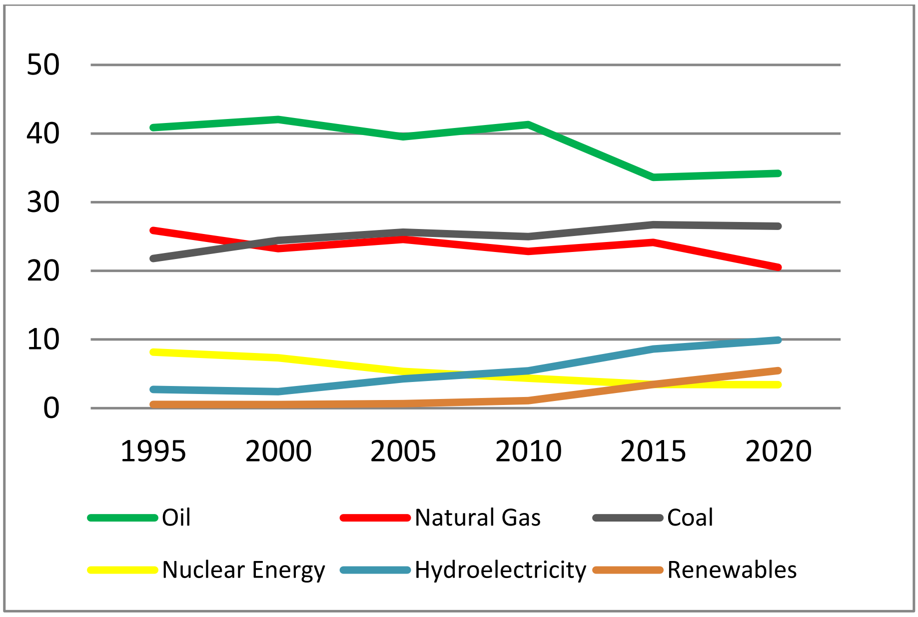

Figure 6. Shares of global primary energy (percentage). Source: latest estimates of the International Energy Agency in 2020.

Another useful element in the objective estimation of the transition to green energy would be to visualize the real situation in which the main geopolitical areas in the world are at the moment. From Figure 7, we notice its importance globally, whereby it varies between 67% and 100%. As a result, we can assume, with sufficient accuracy, that this is the same situation as in the year 2022.

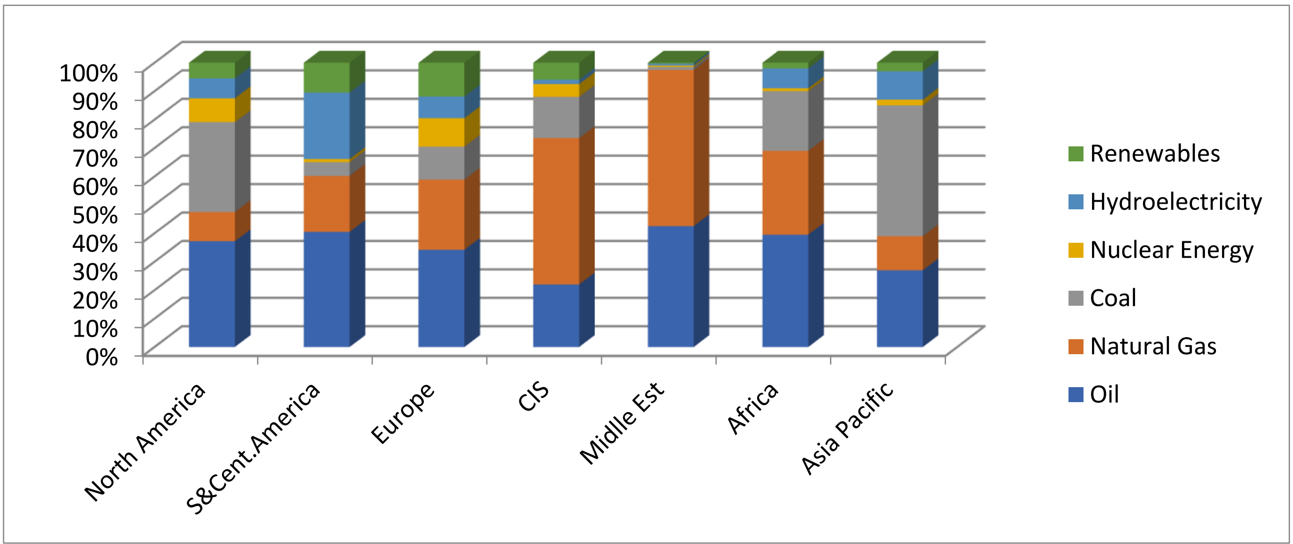

Figure 7. Regional consumption pattern 2020 (percentage). Source: Statistical Review of Word Energy.

Oil remains the dominant fuel in Africa, Europe, North America, and South and Central America, accounting for 30–40% of total primary energy sources. Natural gas dominates the CIS (most of the former USSR) and the Middle East, accounting for more than half of the energy mix in both regions. Coal is the dominant fuel in the Asia-Pacific region. In 2020, the share of coal in primary energy fell to its lowest level in North America by about 12%, and 9% in Europe, respectively, in oil and natural gas; it practically has a 100% energy mix based on fossil fuels, and Central America has an approximate nuclear power slightly higher than that of North America. However, it is equally true that Europe has, and will continue to develop, the first position in the share of unconventional renewable sources in the energy mix (about 12–13% in the year 2020, but with high growth availability in the current decade).

Turning now to the essence of the problem, namely, the gradual transition to the clearly defined goal, Net Zero Carbon 2050, we must ask the natural question: Is this goal achievable in a relatively short time, compared to other profound changes in the energy mix along the history of human civilization—under conditions in which technological progress and economic growth, progressively ascending from one year to another, will remain fundamental indicators of human civilization?

The approach to the intelligent use of these renewable/non-renewable and non-polluting energy resources—in the sense of very low greenhouse gas emissions—must take into account both their advantages and disadvantages compared to conventional fossil sources. The categories of primary energy sources are: nuclear energy from the use in fission reactors of heavy radioactive elements such as uranium or plutonium; nuclear fusion energy of deuterium or tritium in combination with oxygen; hydroelectric energy from the potential and subsequently kinetic energy of high- or very high-flow flowing water streams; geothermal energy, where it is accessible; the energy of sea/ocean waves near the shores; wind energy with onshore terrestrial wind turbines and offshore fixed or floating marine turbines, respectively; photovoltaic energy using, as primary source, the light received from the sun in simple or hybrid mode (in combination with capturing the radiant heat of the sun); a range of multiple biofuels or low CO_2-emitting materials via burning; and last, but not least, the production and use of green hydrogen under conditions of acceptable economic and energy accessibility.

It should be noted, firstly, that fissioned hydroelectric and nuclear power plants—although they can have an absolutely significant contribution to the total energy balance and are already widely used on almost all the continents of the world—have a number of major disadvantages, necessary transitions imposed by the deadlines accepted by the UN member states. We refer, here, to intermediate terms, as the EU has set a 55% reduction in GHGs by 2030 or to the global Zero Net Carbon 2050–2060 deadlines globally.

The design, construction, and commissioning of these power plants requires very long times in the design-commissioning cycle and flood lands—hence the investment costs become extremely high, even if later, the operating costs are practically insignificant, being reduced exclusively to the costs of maintenance and, possibly, repairs. For hydro-energy the surface energy density is extremely low, that is, a maximum of 0.1 W/sqm; this is lower, even, than in the case of biomass/biofuel, where the values are between 0.08–0.13 W/sqm.

At fissioned nuclear power plants, although the surface energy density is high—second only to natural gas—it also means very long times in the design-commissioning cycle. At the same time, investment costs are very high to meet the growing demands for performance and safety indicators imposed by the project.

Other major disadvantages for hydropower plants are the restriction of areas currently allowed for the installation of such investment objectives, areas that must be outside those declared as protected natural areas. In other words, the truth is that animal aquatic life and vegetation in rivers and streams suffers greatly, leading, especially in the case of multiple dams on the same watercourse, to a drastic decline in biodiversity.

In addition, in the case of dams equipped with water-storage lakes, significant methane releases have been found. The flows of watercourses decrease significantly during periods of drought, as do the water level in these lakes, and there is a severe decrease in the amount of energy produced; there is a stagnation of water in the accumulations, with the formation of fermented vegetation and with methane releases into the atmosphere; within 20 years, it is about 80 times higher than previous levels of methane.

On the other hand, at nuclear power plants—no matter how demanding the safety measures—the risks of devastating accidents such as Chernobyl or Fukushima become extremely high in the event of terrorist attacks or, more likely, in the event of natural disasters in the plant area. In addition to the risk of a reactor explosion, another major problem is the deep storage of radioactive waste in the ground after the depletion of fissile material, which must be stored for hundreds of years, due to the enormous half-life of uranium and plutonium isotopes.

For nuclear power plants with thermonuclear fusion—**if they could be built on Earth**—both the risk of explosion and the risk of waste storage are virtually out of the question. Nuclear fusion is the process by which two atomic nuclei react to form a new nucleus, heavier (with higher mass) than the initial nuclei, and release massive energy. In addition, energy production is much stronger than any other known energy source. The fusion of atoms in a controlled way releases almost four million times more energy than a chemical reaction, such as burning coal, oil, or gas, and four times as much as nuclear fission reactions (at equal mass).

It should be noted that nuclear fusion is the main source of energy in active stars. As a result, it is considered, by far, to be the ideal source of energy for human civilization.

Unfortunately, such a nuclear power plant is currently virtually impossible to achieve, because it involves obtaining huge temperatures of hundreds of millions of degrees, with hydrogen in a state of plasma-type aggregation. However, researchers are investing heavily in research on this topic. Thus far, only laboratory thermofusion processes have been obtained, with no applicability in practice. *As such, it should be noted that despite major disadvantages and major inconsistencies with the current situation, hydroelectric power plants with or without storage lakes (micro-hydropower plants) and fissioned nuclear power plants remain essential options for increasing non-fossil energy in order to achieve the proposed objective.*

Non-polluting renewable resources usually have a much lower surface energy density than low-polluting non-renewable resources (nuclear energy, currently accepted as green fuel relative to specific carbon emissions). An illustration of the terrain required to generate a unit of energy through the various systems examined (i.e., the spatial footprint) is given in the following Figure 8:

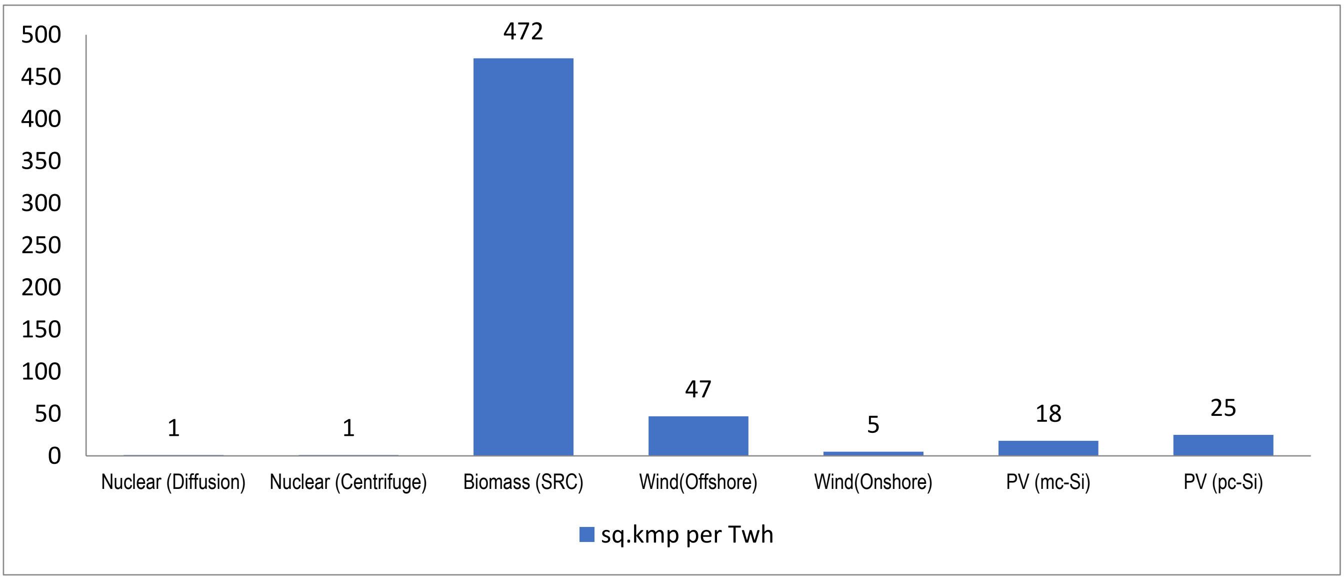

Figure 8. An illustration of the terrain required to generate a unit of energy through the various systems examined (i.e., the spatial footprint). Source: Spatial footprint values determined by Gagnon et al. and the US Environmental Working Group (EWG) for various primary energy sources.

From the point of view of the land surface necessary to produce an amount of energy of 1 Twh, we can practically eliminate biomass/biofuel from our preferences, because its surface energy density is extremely low. Remarkably, apart from nuclear power by diffusion or centrifugation, which requires infinitesimally small surfaces to produce 1 Twh of electricity, it is interesting to note the very small value of the land area required to produce one Twh of electricity in onshore wind turbine systems. From this diagram, we can easily deduce that onshore wind energy has a significantly higher surface energy density than offshore wind. It can also be seen that even photovoltaic energy has an energy density higher than offshore wind turbines—at least double. The mc-Si type monocrystalline photovoltaic panels have a higher surface energy density than the pc-Si polycrystalline type.

The specific energy densities of fossil and non-fossil fuel power plants should be highlighted in order to have a correct picture in this regard, as it can be seen in Table 5:

Table 5. A comparison of spatial fingerprints on the output unit of different power generators. Sources: L. Gagnon, C. Belanger, Y. Uchiyama—Life cycle assessment of electricity generation options: the state of research in 2001, and L. Gagnon—Electricity generation options: Energy recovery rate—Fact sheet Hydro-Quebec, Quebec, Canada (2005).

Energy System	Gagnon et al. (km^2/TWh)	EWG (km^2/TWh)	Present Results (km^2/TWh)
Coal	4.00	3.63	-
Natural gas	-	0.09	-
Nuclear	0.50	0.48	0.30
Wind	72.00	2.33–116.66	1.15–44.17
PV	45.00	13.50–27.00	16.17–20.47
Biomass	533–2200.00	1320–2200.00	470.00

It is easy to see that the smallest space footprint is that of natural gas-fired power plants, closely followed by those with nuclear-powered fission power. This is good from the perspective of the more intensive use of land in the future for construction and urban arrangements; industrial–agricultural or military constructions and arrangements; plantation agriculture, fruit growing, viticulture, pasture for cattle and other domestic animals/birds for human consumption; and last, but not least, the growing areas of reforested or even deliberately forested areas to increase the capacity to absorb CO_2 in the process of photosynthesis.

For one of the most targeted and revolutionary renewable green energy sources in the near future, namely mono- or polycrystalline photovoltaic panels, many specialists were initially very excited about two possibilities that would lead to an extremely high surface energy density:

Option 1: Placing the photovoltaic panel batteries directly on the flat or sloping roofs of typical residential or even industrial buildings can only be applied if the buildings in question are developed mainly horizontally and do not require relatively high electrical power; however, they are not sufficient to supply buildings with predominantly vertical development, with many levels of living, or even those that meet this condition, but are equipped with high-power electrical appliances and equipment. The shapes of cubes or frustoconical elements have truncated pyramids open to the upper flat face, thus increasing the capacity and duration of capturing photon energy and, thus, increasing the specific electrical power on the flat surface unit supporting the UV panels [40]. UV paneling of the vertical walls of the building is not a solution, as the angle of incidence of solar radiation is not efficient, not to mention that some vertical areas of the building will be inherently shaded during the day. In addition, serious problems with building architecture and natural lighting would arise.

Option 2: The location of the batteries of photovoltaic panels in huge numbers, effectively forming a photovoltaic power plant on lands that cannot have another purpose; they are simultaneously placed in areas with solar coverage and implicitly strong photonics all year round, and practically in the largest. Such an optimal location would be found in the great terrestrial deserts of the world, where the daytime sunlight is strong and the rains are extremely rare, which means that there is no cloudiness during the whole day; this avoids the transport of energy produced over long distances, by converting direct current to alternating current, through high voltage lines. These plants could be combined with underground freshwater electrolyzers from vertical drilling in areas with deep aquifers, or from pipelines to produce and store green hydrogen as a direct fuel, synthetic or used in hydrogen–oxygen fuel cells. Unfortunately, two major problems will have to be solved: 1. Protection and frequent and difficult maintenance with a relatively high quantity of water consumption of sand-impregnated panels caused by frequent storms in these big areas. On the other hand, due to the large temperature differences between day and night in dry deserts, condensed water vapor will appear on their surface, which could attenuate the pollution effect given by the desert wind's impregnation and adhesion of sand on the water film resulting from condensation; 2. At very high temperatures during the day—as in arid deserts—the efficiency of photovoltaic panels decreases significantly (on average by about 1% at a temperature increase of 3 °C, above the standard temperature of 25 °C) and can also form so-called heat islands; this is due to the accumulation of radiant heat from the sun and that released by the operation of photovoltaic panels through the passage of electricity through the cells, amplifying the decrease in the efficiency of conversion of photon energy into electricity in the panels. The phenomenon is similar to urban heat islands in paved areas, and with heavy car traffic during hot summer days, is performed at very low temperatures—see the case of the International Space Station outside Earth's atmosphere. With the same reason for the formation of heat islands, the heating of the area planted with photovoltaic panels will increase significantly, leading, to some extent, to releases into the atmosphere that will, at least theoretically, amplify the global average temperature.

Another renewable energy source that is highly targeted and already developed in many countries around the world is onshore and offshore wind energy. The United Kingdom is a true Saudi Arabia of wind energy; this is obvious in the context in which both the UK and Ireland are surrounded by coastal and distant sea waters, with great wind potential here being very strong, and with consistent winds.

It is already intuitive that if the world's major economic superpowers decide to give up the huge spending in the arms industry, both conventional and unconventional, investments in wind energy will be able to give a great chance to humankind. Both onshore and offshore wind will have explosive growth over the next decade. Driven by technological advances and global policies to combat climate change, wind energy is becoming increasingly financially sustainable. China and the United States remain the largest wind energy markets in the world, and the countries of the United Kingdom and Europe, North America, and India are leading the trend of fast-growing wind development. Next, it would be necessary to review a number of advantages and disadvantages of onshore and offshore wind energy.

In addition to the obvious benefits of sustainability, what else is good about onshore energy? The infrastructure required for onshore wind energy is significantly less expensive than that required for offshore wind energy. In some cases, it is half the cost and can be paid off in two years. It is also the least expensive form of renewable energy compared to solar and nuclear energy sources, which means it is more affordable for consumers. As they are cost-effective, onshore wind farms tend to be larger, producing more energy on site. In addition, with a smaller distance between the turbines and the consumer, there isa smaller voltage drop in the wiring. On the other hand, onshore wind turbines are quickly installed and can be built in a few months, unlike other viable energy sources, such as nuclear power plants, which can take more than two decades to build and put into operation. When in operation, onshore wind turbines also have low maintenance costs. Onshore wind farms have a lesser physical impact on adjacent areas. The land on which wind turbines are located can be cultivated or used for any other purpose and there is very little impact on wildlife, less than any other type of renewable energy, which is equivalent to a higher surface energy density than other green energy resources.

Of course, there are serious disadvantages to these onshore wind turbines. One of the most relevant is that variable wind speeds occur, and they are usually designed for a range of 15–88 km/h. However, in reality, the speed of onshore wind turbines is somewhat unpredictable. Because wind speed and direction vary on land, achieving consistent energy production can be a challenge. As a result, the speed and direction of the wind must be carefully monitored to plan for power generation. Another important aspect is that physical blockages of wind can occur due to buildings and the surrounding landscape, such as hills or mountains, which can also cause production inconsistencies. For this reason, onshore wind cannot produce energy all year round, and the usual maximum electric power can be only about 2.5 MW, compared to about 3.6 MW with offshore wind. It should also be noted that because onshore turbines do not operate year-round, they require fossil fuel reserves when wind speeds are low. As we rely more and more on wind farms for our energy, more and more fossil fuels will also be needed for the population in the area. Onshore wind farms can be a landscape crisis. Wind turbines that are built on high ground to generate more energy may be imposing on surrounding residential areas. Wind turbines are also not quiet, which means that they cause noise pollution if they are located near a residential area. To illustrate, up close, a wind turbine sounds like a lawn mower.

In general, however, the benefits of onshore wind energy and the sustainable energy it can create outweigh the potential disadvantages. Offshore wind energy refers to wind farms that are located above the shallow open water area, usually in the ocean, where there are higher and more constant wind speeds. The term "offshore wind" can also refer to coastal water areas, such as lakes and fjords. Most offshore wind farms use fixed-bottom wind turbines in shallow water. However, as technology advances, wind farms will be able to be built in deeper waters.

The advantages of offshore wind are that it can generate more energy compared to terrestrial turbines, because offshore wind speeds are usually faster than on land, and even small increases in speed can result in large increases in power generation. As such, fewer turbines are needed to produce the same amount of energy as a turbine on land. It also provides more consistency, because offshore wind speeds do not vary as much and wind direction does not change so often, so offshore turbines are more consistent (meaning more reliable power generation). In other words, offshore urban areas do not have as much visual impact as those on land. They do not interfere with land use and there are no physical obstacles that can interrupt the flow of wind. For this reason, offshore wind farms can be enlarged and generate more energy than onshore wind farms, with less physical impact. At the same time, offshore turbines can also be built taller than onshore wind turbines, which means they can use more wind energy and produce more electricity [41].

The disadvantages of offshore wind are also significant and many. It is very important that there are much higher maintenance costs compared to the onshore version. Sea waves and very strong winds can damage turbines, so they need more maintenance than their onshore counterparts. Offshore wind farms are also difficult to access, which means longer waiting times for repairs. The appearance of visual and sound discomfort should not be neglected either. Underwater turbine noise can affect wildlife and other marine life. In addition, not all offshore wind farms are built out of public view. Some are built within a radius of 26 miles of the coastline, so they may still be extremely visible to local residents. In other words, unlike onshore wind farms, offshore wind farms have a limited capacity to benefit local economies. As manufacturers' offices are located inland and often away from the offshore site, no jobs are created in the local community and no other investments are made.

Despite these serious disadvantages, the offshore option seems to be attracting the attention of national economies and private investors, especially through energy efficiency and the large surface area available offshore and in oceans, not affecting the land area increasingly demanded by all other economic activities. This is all the more pertinent as the so-called fixed/floating wind turbines, with high mechanical stability in the face of strong winds and waves off the seas and oceans, have begun to develop strongly, where due to the depth of the waters, fixed turbines can no longer be built. It is a viable solution. Moreover, the most recent projects bring into question an element of great economic value, namely that of coupling these turbines with electrolyzers for the production of green hydrogen via electrolysis directly from desalinated sea/ocean water. In these conditions, practically, in the presence of consistent winds and constant offshore parks, turbines will be able to operate non-stop, without following the concordance between the production and consumption of electricity; this is a huge advantage, a local energy system. Additionally, if the distance between oceanfront sites and shore consumers is too great, the function of transporting electricity can be abandoned, reducing turbines to the production of hydrogen from renewable energy; the only way to electrolyze water could be a logical and cost-effective way to produce hydrogen, which is then used as a total clean fuel. The rise in the share of various renewable energy resources in the global green energy mix—in the last decade—has had an evolution that highlights the fact that the two sources presented above have gained serious ground in the modern energy mix.

The global energy sector is witnessing a gradual transition from conventional heat-generation sources to clean-energy technologies. The ambitious renewable energy targets set by countries around the globe indicate a growing share of renewable energy sources in the global energy mix over the next 20 years. The share of renewable sources was 8.6% in the global energy mix in 2010 and increased to 22.5% in 2020, according to a recent thematic research report Renewable Energy by GlobalData.

The total installed capacity of renewable energy sources was 437 GW in 2010, with a share of 8.6% in the total global installed capacity. It increased more than 2.5 times to 1236 GW in 2017 and had an installed capacity share of 18.2%. Wind energy was the largest renewable source, with a share of 44.2% of the global renewable energy capacity in 2017, followed by solar photovoltaic (32.4%), small hydropower (11.7%) and bioenergy (10.1%). In the year 2020, the total installed capacity of renewable energy sources was 1734 GW and the share of renewable energy sources increased to 22.5% in the total global installed capacity. These figures can be found in the pie chart from Figure 9 below:

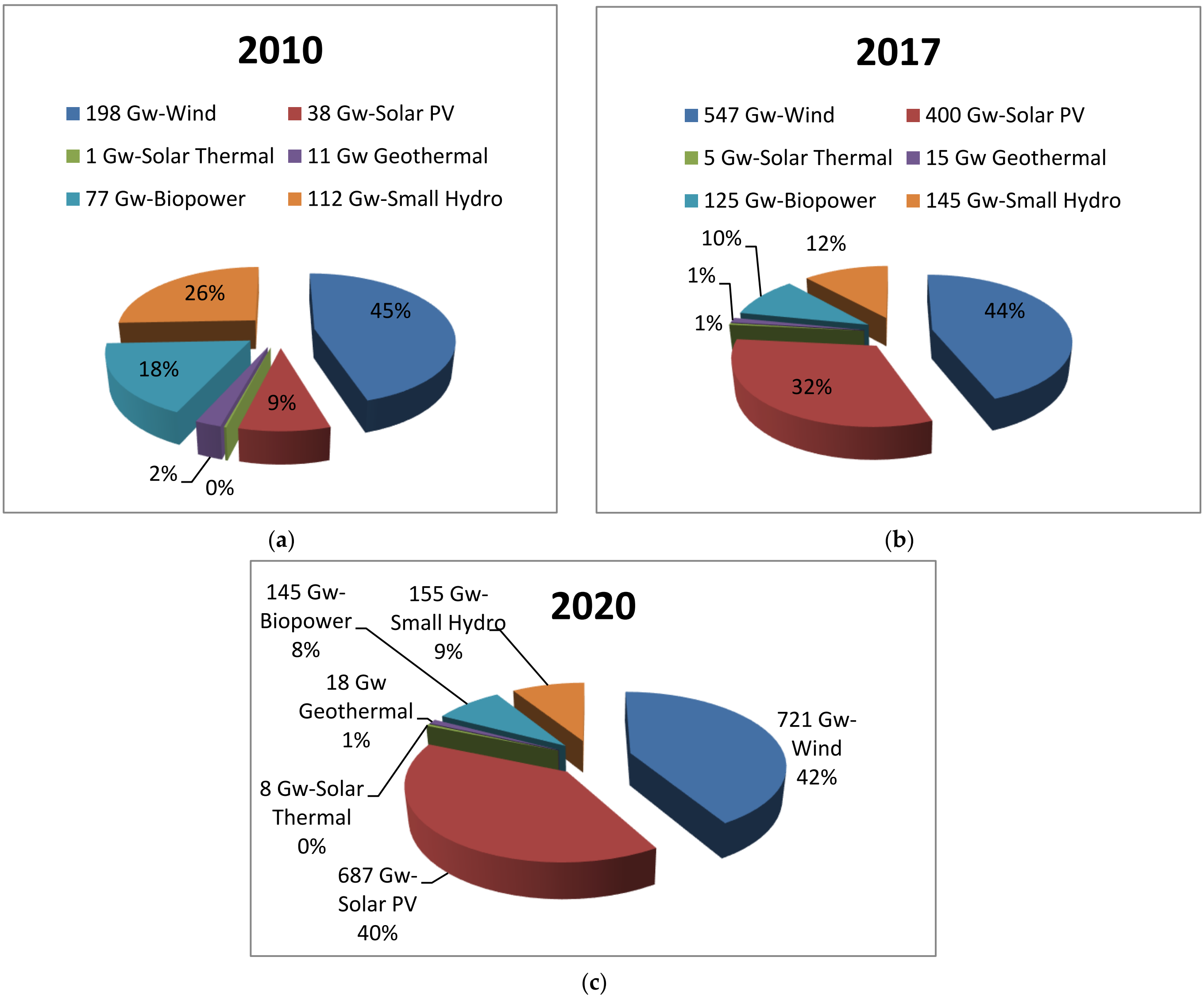

Figure 9. Renewable energy market, global, capacity share installed on energy generation source (%), (**a**) 2010, (**b**) 2017, (**c**) 2020.

The diagram shows the latest trends in the evolution of renewable energy sources at the end of the second decade, namely, the clear increase in the share of onshore/offshore wind energy and photovoltaic energy, to the detriment of other previously used sources: small hydropower plants, geothermal, biomass and biofuels, and solar thermal energy.

Until now, electricity from renewable sources has been expensive compared to electricity from conventional sources, and therefore, government support for incentives and subsidies plays a crucial role in supporting renewable development. Due to technological advances, wind and solar are becoming more and more attractive in terms of costs. Onshore wind technology, in particular, has evolved into a well-established and mature technology with a low cost of generation.

Renewable projects are now starting to compete on costs rather than subsidy support, so renewable energy is expected to become a profitable and competitive source of electricity generation in a number of countries in the coming years. Wind and solar photovoltaic technologies will continue their growth trajectory as the generation costs involved in these sources become more and more competitive, thus encouraging the establishment of more projects in the coming years. The emergence of newer markets will further stimulate the adoption of wind and solar energy sources. Initially, governments sought to encourage solar and wind installations through tax promotion schemes. Decreased costs have made it possible for these schemes to be replaced by reverse bidding mechanisms, leading to a boom in the construction of utility-scale energy projects. Such booms have been more pronounced in the Asia-Pacific region, in countries such as China and India, and in countries in South America, such as Brazil and Chile.

5. Non-Polluting Renewable Energies, the Power of the Big Cities, and the Intelligent Metropolis of the World

As the world's cities expand, so does their energy consumption. Additionally, as cities strive to become "smart", solar and wind power can play a crucial role in helping them achieve their goals. It should be noted that the small geographical footprint of cities contradicts their significance. They cover only 2% of the earth's surface, but represent the majority of the world's population, economic activity and energy consumption related to economic development. Here, we focus on one key issue—energy use—as cities and renewable electricity have become the global habitat and energy of choice. The two entities are increasingly inseparable. As cities struggle to attract growing business, talent, and innovation into increasingly global competition, solar and wind power have become key to many in achieving their smart city goals.

The goals of a smart people-centered city are economic growth, sustainability, and quality of life, while the goals of a utility are to provide reliable, accessible, and environmentally responsible energy. Solar and wind energy are the pillars for aligning and achieving both goal sets. In order to better describe cities that recognize this and capitalize on wind and solar energy, the concept of smart cities from renewable sources (SRC) has been developed. SRCs are already powered by solar and wind energy and plan to further implement these sources as an integral part of their smart city plans.

Cities and utilities, in general, and energy utilities in particular provide leading, growing, and transforming platforms for human activity. Cities form the main habitat platform for human activity, and utilities' electricity grids form the main energy platform. Most of the world's population lives in electrified urban centers; areas where this is less so record some of the fastest growing urbanization and electrification rates. Representing 70% of global energy consumption, cities are the main growth area for utilities. The city and utility platforms are sometimes adjacent and sometimes overlap in their geographical areas and assets. For example, municipal utilities fall within the remit of their city, while utilities owned by investors cannot; street lights can be owned by the city or utilities. The current and potential growth of both platforms is enormous, as cities interconnect to form and grow into megacities (which have 10 million or more people) and as electrification expands into new sectors such as transportation. As these platforms expand, their borders blur: where does a city end and suburbs begin? Where does the jurisdiction of utility and that of other energy and service providers end? In both cases, how should the two relate? Additionally, who are the stakeholders? The limits of the possibilities of cities and utilities are also changing as the inherited infrastructure is equipped with connected technology. The importance and complexity of city and utility roles have grown with the imperative to be "smart".

Smart cities and utilities share a common interest in implementing two energy sources that align with their goals: solar and wind. Utilities adopt wind and solar energy as they reach parity in price and performance with conventional energy sources around the world; this helps them to balance the cost-effective network and become more valuable assets due to the increasingly cost-effective storage of other new technologies [42]. These renewable energy sources are now the closest thing to meeting the growing demand for reliable, affordable, and environmentally responsible energy sources that utilities are trying to provide. As a result, renewable energy sources have become the preferred energy sources for key consumers, such as cities. Another key consumer that is valuable to both cities and utility providers are corporations, which purchased record amounts of renewable sources in 2018. Unlike most energy sources, wind, and especially solar energy, can be used in and by the city. Finally, solar and wind energy are citizen/customer-centric energy sources, as many residents and businesses require these renewable sources and are increasingly empowered to implement them on their own properties and buildings, or to purchase parts of projects, solar and wind energy, or energy from the community initiatives.

6. Conclusions

Smart cities have a growing opportunity and imperative to become SRCs. Integrating more solar and wind energy sources into cities' energy mixes can directly fuel their goals to become more economically competitive, sustainable, and viable. In fact, these goals cannot be achieved without a significant share of renewables. Utilities play a key role in their successful implementation, as electrification powered by both utility-scale renewable energy and renewable energy distributed in the construction and transportation sectors, unlocking new opportunities for customer involvement, are essential for this transition.

The purest SRCs have already changed the equation, presenting smart cities as a component of their renewable energy plans, recognizing that renewable energy is a starting point for smart cities. Both cities and utilities should be bold in their SRC journeys, as growth is not guaranteed. Cities are competing with each other, while utilities may risk losing business and other opportunities to non-traditional electricity suppliers. The first cities and utilities to obtain 100% renewable sources could reap the greatest reward, as they attract a growing number of similar stakeholders.

1. All buildings for industrial, administrative, and residential purposes must comply with the nZEB ("nearly zero energy building") standard—i.e., have almost zero energy consumption, provided largely by renewable sources, but also by a high degree of energy efficiency, through thermal insulation close to the standard of the passive house.
2. Establishing strategies and techniques to reduce high energy consumption, both in the industrial area and in the commercial, administrative, and residential area, starting from the use of the most competitive thermal insulation materials that can dramatically reduce heat loss flows, inside and outside as well as vice versa; these should be specific to winter and summer periods, respectively, and force or light will advance the implementation of high-energy-efficiency equipment.
3. The widespread use of wind, photovoltaic, and solar thermal energy—both in the direct area of civil, administrative, and corporate building sites related to large metropolises, and especially in areas specially created in the adjacent service spaces of megacities, where the main economic entities of production would also be located—would lead to a maximum performance energy of all kinds required by the economic, commercial, entertainment, and living life of these megacities.
4. An essential step in the lives of those in large metropolises will have to take into account the vastness of waste of any kind that will come out of their consumption circuit and their recovery in the consumption cycle, but others with predominantly organic waste, to be collected separately and sent to biofuel stations in the adjacent area, specially arranged in the suburbs of the metropolis. It is probably the most important aspect of clean life and energy efficient in big cities. It is not easy, but it is absolutely essential.
5. The timely collection and monitoring of data on energy flows and recyclable waste will have to be conducted automatically and centrally for a given metropolis, through the widespread use of intelligent AI systems, implicitly, for capitalization at maximum efficiency and at the optimal operative times of all these renewable and revaluable resources.

6. An essential technical-energetic element of the new megacities will be that of the large-scale introduction of the highly publicized heat pumps, in a reverse refrigeration cycle—with a COP of at least 5, as a ratio between the actual energy produced by the PC assembly and the electrical energy consumed by the refrigerant compressor in the compression cycle, respectively. It is probable that, compared to the financial and strategic value of the land area in megacities, the far more optimal option would be that of using water- and soil-type PCs, with vertical drilling.
7. Even if the electric propulsion of individual or public transport over the vast surface of megacities cannot directly supply the global concentrations of greenhouse gases worldwide, the massive introduction of electric transport would drastically reduce the level of chemical pollution in cities. In addition, it will create the optimal conditions for charging/recharging car traction batteries from "green" sources, which are abundant in the territory of these megacities, and improve the psychological and financial situation of all owners of electric cars.
8. Taking into account the significantly reduced capacity factor of onshore and offshore wind installations, and especially photovoltaic ones, all these local power plants will have to be interconnected with a regional or state energy system, still based on energy production: gas-fired power plants, in combination with or without CCUS; large hydroelectric power plants that are already built; small hydropower plants without storage lakes; and, especially, modernized or state-of-the-art nuclear power plants. Both individually and at the level of the "green" local power plant, the prosumator system will be adopted—without storage batteries—with two-way circulation of the produced energy and endowment with intelligent meters to a classic SEN to meet its needs. As in the case of the overproduction of green energy, it will be possible to inject into the SEN, with monitoring of the energy transit in both directions, for financial compensation of the acquisition costs.
9. A special case—perhaps the most advantageous—is that of the coastal metropolises, cities open to the sea or the ocean, the so-called coastal metropolises. In these areas, of course, the adjacent presence of the ocean brings a huge advantage: offshore wind farms in the neighboring area of the metropolis. Here, the land is not affected and can be used in its entirety as potential residential, corporate, ecological, and any other urban development. This is based on the indisputable truth that most green renewable resources have a much lower surface energy density than the densities of conventional fossil or nuclear resources. In this case, moving the energy production area outside the land area, closer or farther from the shore, will bring an enormous urban advantage, combined with a very high energy efficiency.
10. It is probable that the most consistent technological solution in the direction of the sustainable transition to green energy—both globally and, in particular, in the case of smart metropolises—is represented by the massive production of hydrogen fuel via the process of water electrolysis and its hydrogen and oxygen, which is a powerful energy-consuming process. The only economical way to produce hydrogen for energy is to use it as a primary source of renewable energy, especially the part that would be lost from production anyway. This is the case when there is an imbalance between the amount of electricity produced and the amount of electricity requested by consumers in the area served by those green sources. During these periods, the excess energy should be stored in power batteries and then redistributed in the system, or if this solution is not feasible, then simply, wind or photovoltaic generators should be shut down during the entire consumption. When we talk about floating/floating offshore wind sources—the distribution of electricity through a network of long-distance marine cables—it becomes very expensive, and it is preferable to continuously produce hydrogen accumulated in our own tanks included in the turbines. A similar situation occurs in the case of onshore wind or photovoltaic parks, located in areas of high energy potential, but located at great distances from the area of potential consumers of electricity—economic or residential. Green hydrogen could also become

an extremely convenient solution for heavy and long-distance transport on land, sea, or air. The hydrogen obtained can be used as such as a direct fuel, or via processing in low-polluting synthetic gases with a calorific value higher than hydrogen. However, the most convenient option would be to use hydrogen–oxygen fuel cells, adapted accordingly to common destinations in transport; these have previously been used only in special applications, usually in space and in pilot projects.

Author Contributions: Conceptualization, N.M., D.H. and D.V.; methodology, D.H.; validation, N.M. and D.V.; formal analysis, D.H.; resources, M.R.S.-P. and V.E.; writing—original draft preparation, M.R.S.-P. and V.E.; writing—review and editing, A.Ş.C., A.I.C. and A.B.; visualization, V.E. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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