

## THE LIMITED CONTRIBUTION OF SUSTAINABLE RESOURCES IN THE ELECTRICITY INDUSTRY IS A CHALLENGE TO CLIMATE TARGETS.

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**Abstract**—In the world, only a few countries have managed to produce electrical energy using renewable resources as their main input, rather than fossil fuels and nuclear energy. From a consumption perspective, even fewer nations have been able to meet their needs using electric power first. The above is not trivial given that there is great concern worldwide about global warming, this because of the so-called greenhouse gases, and that efforts have been made internationally to contain the carbon footprint to acceptable levels, such as It can be seen in various forums that derive from the Paris Agreement and the United Nations Conferences of the Parties. The problem could seem simple if it were not for the fact that fossil fuels are considered a relevant factor in the generation of gases that cause global warming, which could contradict the expectations in the use of electrical energy to benefit the environment and consequently the correspond to the electric car industry.

**Index Terms**— Climate change 1; electricity 3; fossil fuels 2; renewable resources 4..

### I. INTRODUCTION

Globally, there has been growing concern about addressing climate change, leading to the formalization of the Paris Agreement [1] and the United Nations' Conferences of the Parties [2]. One of the identified consequences is the phenomenon known as global warming, which is often attributed to the exacerbation of various natural phenomena.

This concern is evident when observing the proliferation of wildfires in various regions of North America, major hurricanes in countries like Mexico [3] and the United States [4], extraordinary flooding levels in Asia [5] and various regions of the Caribbean, accelerated ice melt in Arctic regions [6], to name a few.

To tackle the problem, it is necessary to analyze the issue from different fronts, and in this case, the focus is on energy production. Specifically, it is essential to highlight environmentally friendly energy sources, with this document focusing on electricity. For illustrative purposes, it is important to consider that electricity is significantly produced with fossil fuels, natural resources, and nuclear energy. Therefore, given that fossil fuels are inputs used to generate electricity, there is great concern from a climate perspective since these are considered responsible for greenhouse gas emissions, which in turn contribute to global warming. This situation must be analyzed consistently, starting with the global context, and subsequently identifying the countries that exhibit the most environmentally friendly results.

### II. RESULTS

From the 1970s to 2021, global electricity production has depended on average, more than 60% on fossil fuels, as shown in the graph below. Similarly, renewable resources accounted for 21% during this period.

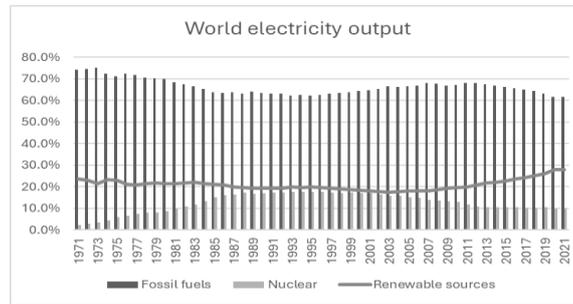


Figure 1. Contribution to total electricity production in the world. Based on data provided by IEA [7].

The graph shows a steady trend of fossil fuel energy sources, fluctuating between 70% and 60% as a significant input for electricity production, while renewable resources show a moderate increase, reaching 1/3 of the total contribution.

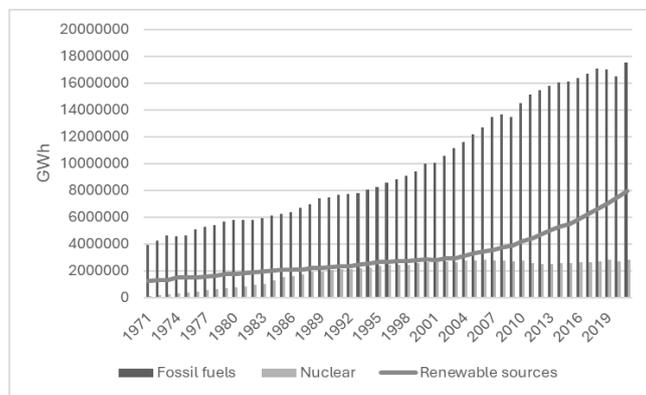


Figure 2. World trend of relevant inputs for electricity production in gigawatt-hours (GWh). Based on data provided by the International Energy Agency (IEA) [7].

From another perspective, electricity production from fossil fuels shows a positive slope, as does the use of renewable resources. However, the former remains the main contributor to the total, while nuclear energy seems to follow a lateral movement and is less significant than other inputs since the 1980s.

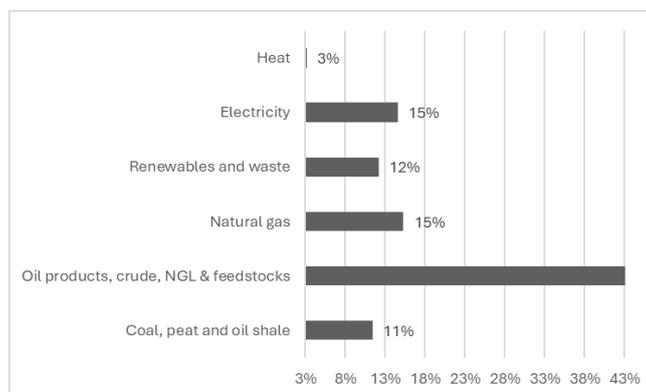


Figure 3. Contribution to total consumption in the world (Average of 50 years). Based on data provided by IEA [7].

Even when referencing the most recent data available from 2021, a situation closes to the average levels observed over half a century can be seen.

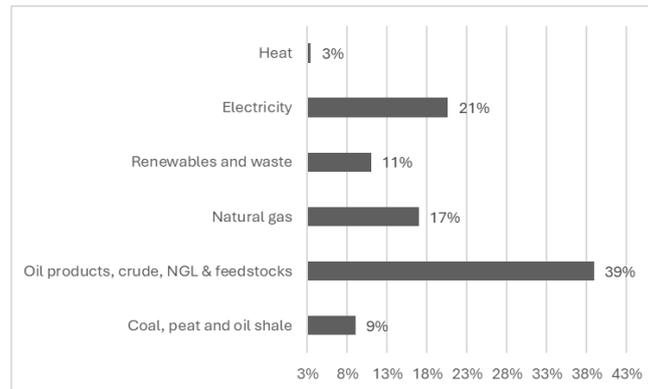


Figure 4. Contribution to total consumption in the world (2021 Petajoules PJ). Based on data provided by IEA [7].

From a consumption perspective, as shown in Figures 3 and 4, the world's main energy source is fossil fuels, contributing 54.8% of the total over the 50-year period and 47.99% in 2021.

On average, electricity accounts for only 15% of the total, and about 1/5 of the total energy consumed in 2021, a little over 5 basis points during the observed period.

Now, after referencing the global situation, both in terms of production and consumption, it is necessary to analyze the data series provided by the IEA (International Energy Agency) [7] to identify which countries deviate from the global average and show a more environmentally friendly situation. This is important because these countries could serve as models for other regions.

From the available data series, Austria, Brazil, Canada, Colombia, Costa Rica, Finland, Iceland, Kenya, Latvia, Lithuania, Luxembourg, New Zealand, Norway, Portugal, Sweden, and Switzerland have been identified as countries that stand out for their use of natural resources in electricity production.

## II.1 AUSTRIA AND ELECTRICITY

According to available data, since the 1970s, Austria has consistently used renewable inputs to generate electricity. More importantly, from an environmental perspective, its situation is better than the global average, contributing more than 60% during the latter part of the observed period.

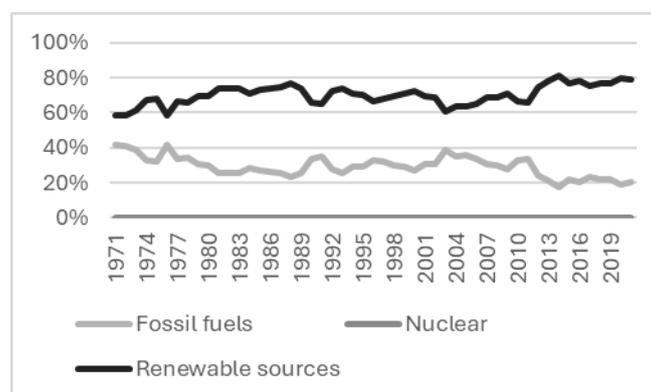


Figure 5. Contribution to total electricity production in Austria. Based on data provided by IEA [7].

Figure 5 shows the percentage contributions of each input and a long-term downward trend in fossil fuel use, reaching close to 1/5 of the total required for electricity generation.

This is a positive sign for the environment, and it is also notable that this trend appears to be structural, as it has been evident for an extended period, even before the climate initiatives of the Conferences of the Parties (1995) by the United Nations or the Paris Agreement (2015). Additionally, the lack of nuclear

energy contribution during the observed period stands out.

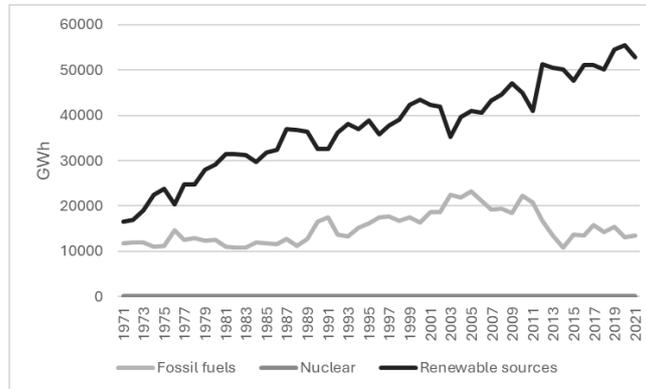


Figure 6. Austria's trend of relevant inputs for electricity production (gigawatt-hours (GWh)). Based on data provided by the International Energy Agency (IEA) [7].

When observing the amount of electricity produced annually, the use of renewable resources is increasing, while fossil fuel use shows a nearly horizontal trend.

This indicates that even with higher production, fossil fuel use has not increased, which is positive for the environment.

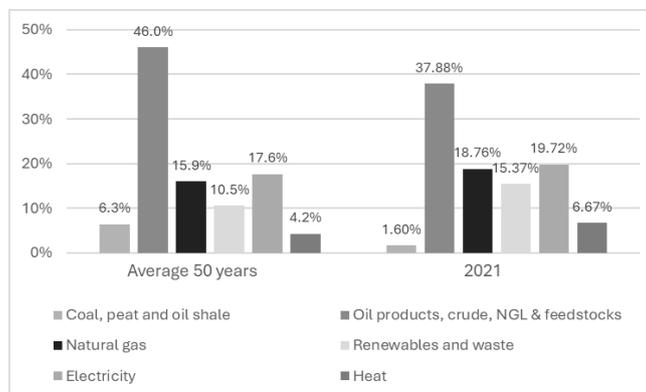


Figure 7. Contribution to total consumption in Austria (PJ). Based on data provided by IEA [7].

However, when considering the country's energy consumption needs, a similar situation to the global record is observed, where the main source of energy in Austria relies on fossil fuels, although with a 5.36% reduction, including natural gas, in 2021 compared to the 50-year average. Electricity ranks second, contributing almost 1/5 of total consumption in 2021.

## II.15 BRAZIL AND ELECTRIC ENERGY

Brazil also shows a structural behavior in electricity production, with a practically lateral trend throughout the analyzed period regarding relevant inputs for generating electricity.

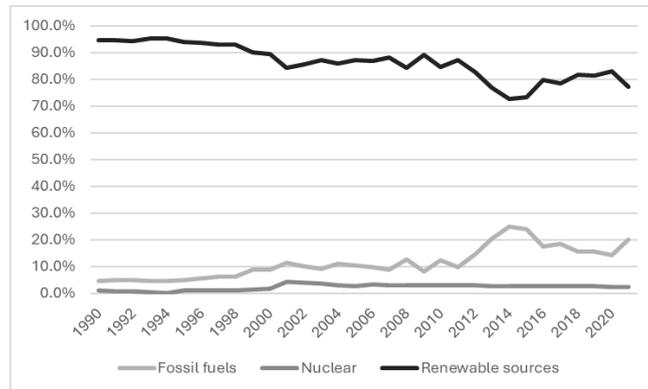


Figure 8. Contribution to total electricity production in Brazil. Based on data provided by IEA [7].

In Brazil, fossil fuels contribute about 1/5, with a slight contribution from nuclear energy, while renewable resources stand out significantly.

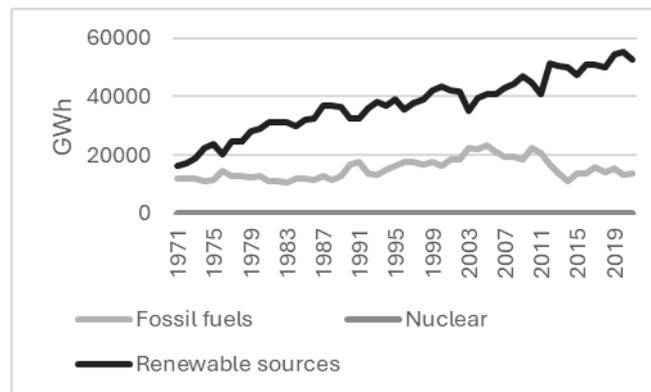


Figure 9. Brazil's trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Figure 9 shows a marked upward trend in renewable resources, with much less dependence on fossil fuels and almost negligible nuclear energy.

It is worth noting that hydroelectric plants in Brazil generate the largest amount of renewable electricity, with expansion projects in solar and onshore and offshore wind energy.

Brazil is also the sixth-largest electrical energy consumer globally and the largest in Latin America [8], this should be further analyzed in future studies.

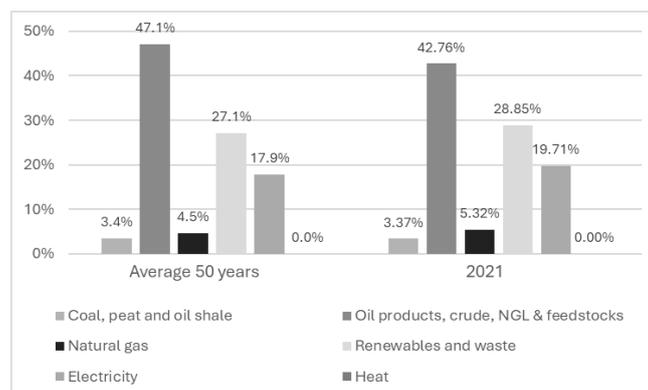


Figure 10. Contribution to total consumption in Brazil (PJ). Based on data provided by IEA [7].

Brazil's main energy source is fossil fuels, followed by renewable resources, and electricity ranks third. There is little change between the average calculated over the observed period and the results shown for 2021.

## II.2 CANADA AND ELECTRIC ENERGY

Canada has a similar situation to Austria regarding the use of renewable resources for electricity production, as shown in Figure 11.

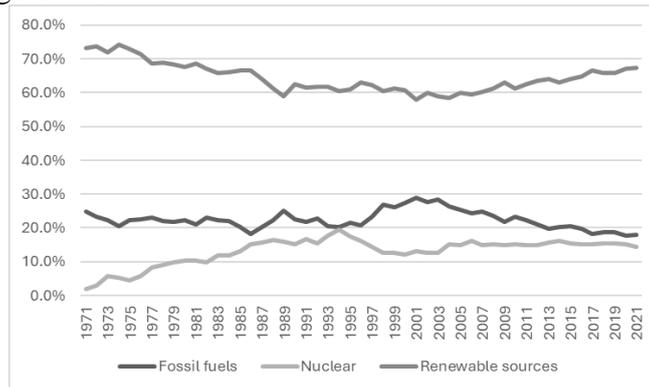


Figure 11. Contribution to total electricity production in Canada. Based on data provided by IEA [7].

In this case, the use of renewable resources as the main inputs is also clear, leaving fossil fuels in second place. Canada also uses nuclear energy, though its long-term behavior is relatively stable.

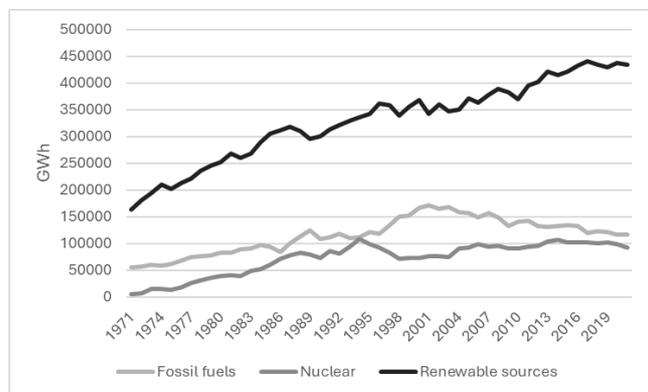


Figure 12. Canada's trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

When observing electricity production in terms of gigawatt-hours (GWh) by input type, renewable resources show an upward trend, while the other two inputs show a moderate upward trajectory before stabilizing. This again suggests that they have the capacity to sustain growth with environmentally friendly resources.

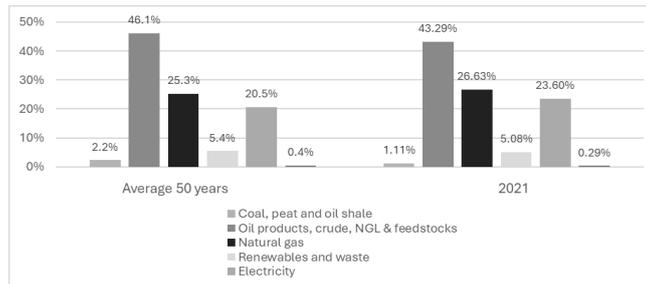


Figure 13. Contribution to total consumption in Canada (PJ). Based on data provided by IEA [7].

In Canada, energy consumption relies on electricity for 1/5 of the total, with just over a 3% increase in 2021 compared to the historical average shown in Figure 13. Fossil fuel dependence also remains significant, accounting for nearly 70% of the total.

### II.3 COLOMBIA AND ELECTRIC ENERGY

Colombia also shows a trend that appears to be structural regarding the consistent use of renewable resources and the contribution of fossil-based fuels.

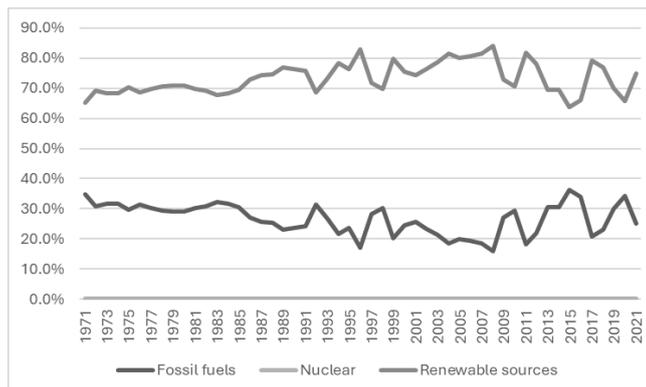


Figure 14. Contribution to total electricity production in Colombia. Based on data provided by IEA [7].

As observed in Austria and Canada, in the long term, the contribution of renewable resources stands out, producing electricity at levels above 60% and, at times, even surpassing 80%. This trend persists throughout the study period. A similar situation is seen with the use of fossil fuels, which cover the remainder of the electricity production needs due to the lack of other types of inputs.

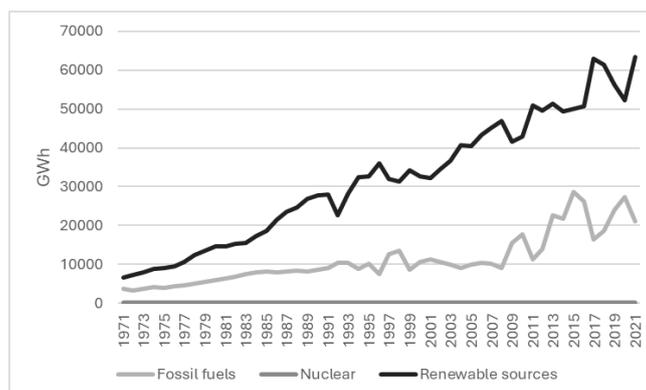


Figure 15. Colombia's trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

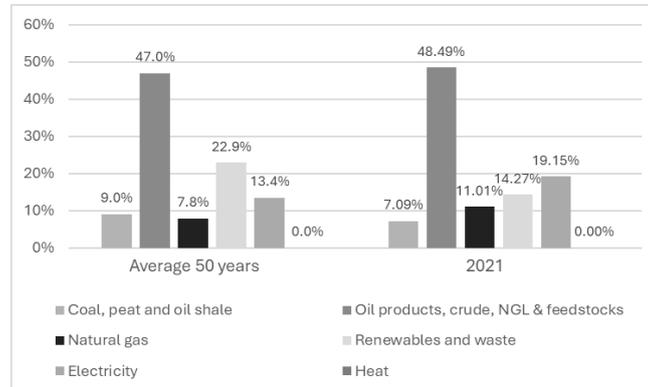


Figure 16. Contribution to total consumption in Colombia (PJ). Based on data provided by IEA [7].

In the long term, it can be observed that in the 1970s, the levels of fossil fuels and renewable resources were very close to each other. However, they have since diverged to a ratio of 1 to 6, respectively, which appears to benefit the environment.

However, when considering total energy needs, a similar situation to Austria and Canada arises, where 60% of consumption in Colombia comes from fossilized resources, and around 20% from electricity.

#### II.4 COSTA RICA AND ELECTRIC ENERGY

The situation in Costa Rica is noteworthy because the inputs used in electricity production show consistent behavior in the long term, with renewable resources nearing 100% in the most recent observation period.

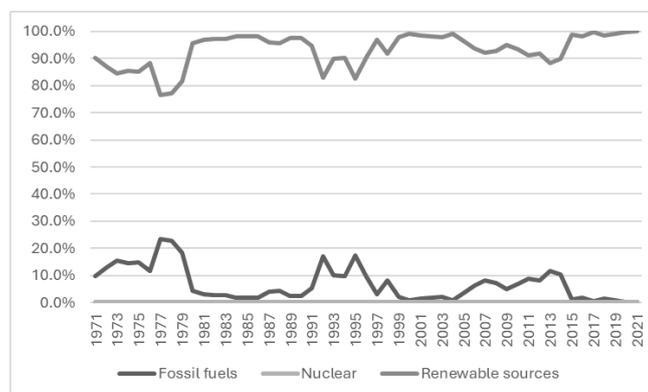


Figure 17. Contribution to total electricity production in Costa Rica. Based on data provided by IEA [7].

It can also be seen that electricity is generated from two sources: renewable resources and fossil-based ones. Both show structural behaviors, with the former fluctuating between 80% and 100%, and the latter at 20% in some periods, later reaching minimal levels in the present decade.

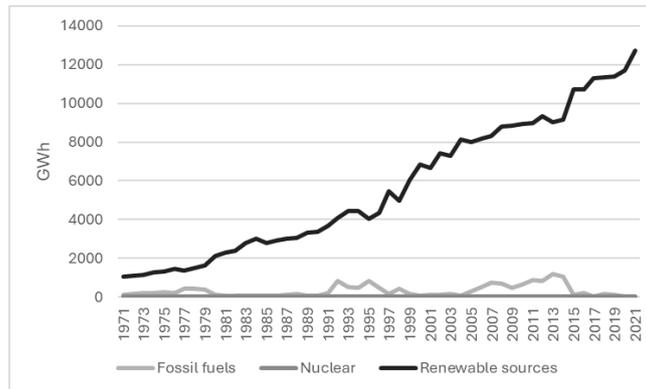


Figure 18. Costa Rica's trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

In Costa Rica, the use of fossil fuels is practically insignificant in the historical period, while renewable resources have increasingly been used for electricity production in terms of GWh.

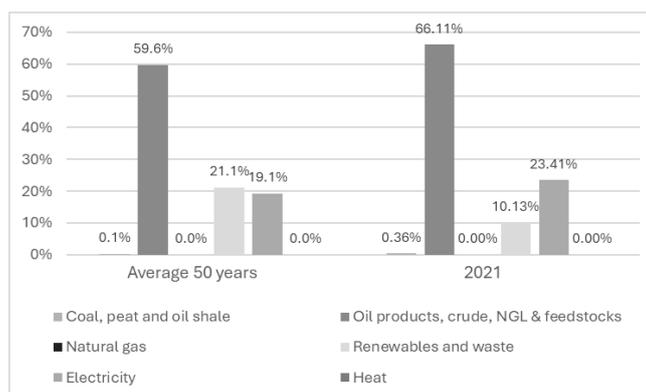


Figure 19. Contribution to total consumption in Costa Rica (PJ). Based on data provided by IEA [7].

Electricity consumption in Costa Rica increased by 4% in 2021 compared to the average for the entire observed period, while showing no dependence on natural gas, heat, or coal.

## II.5 FINLAND AND ELECTRIC ENERGY

Figure 20 shows a long period during which Finland maintained similar ranges between the use of nuclear energy and natural resources, with fluctuations in the use of fossil fuels, especially during the 1980s and into the early 21st century.

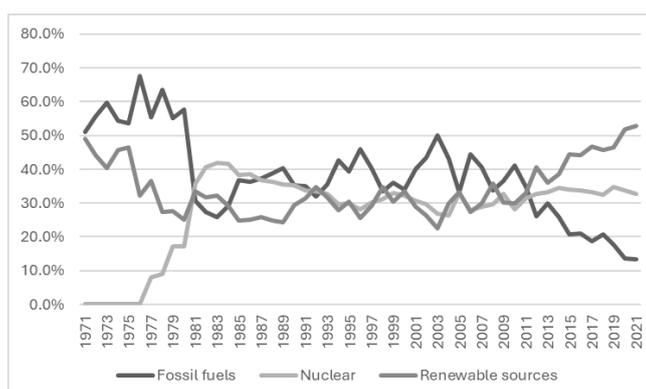


Figure 20. Contribution to total electricity production in Finland. Based on data provided by IEA [7].

Unlike the countries previously analyzed, nuclear energy contributes just over 1/3 of Finland's needs, a trend that has been sustained over the long term. Meanwhile, the use of fossil fuels has decreased significantly, and renewable resources show an upward trend, surpassing 50% of the total. This seems to coincide with the formalization of the 2015 Paris Agreement, which was implemented the following year.

Figure 21 highlights the increased importance of non-renewable energy resources during the 1990s and early 21st century, but this changed dramatically in the present, with a sharp decline from 2013 to 2021. Meanwhile, renewable resources show a growing trend.

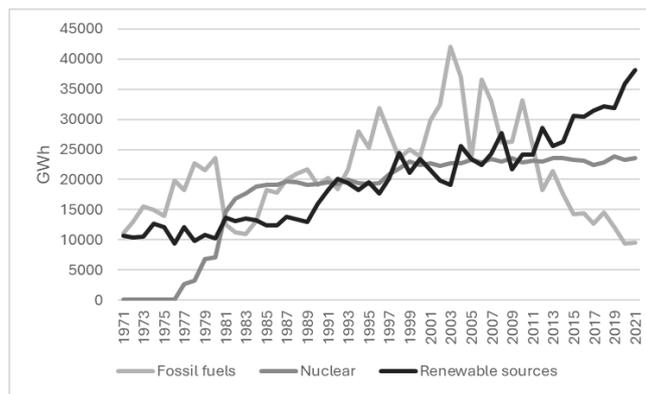


Figure 21. Finland's trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

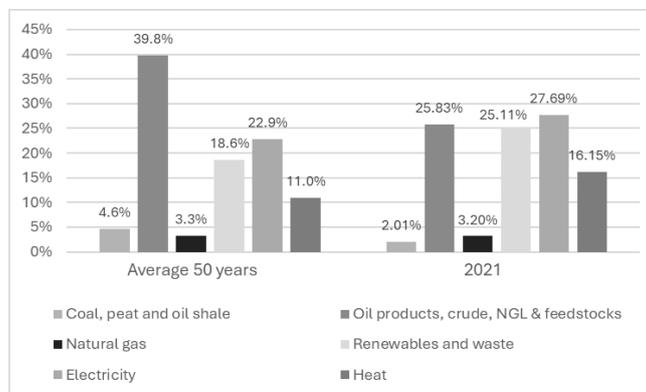


Figure 22. Contribution to total consumption in Finland (PJ). Based on data provided by IEA [7].

From the perspective of Finland's total energy needs, the reduction in the use of non-renewable resources stands out, dropping from an average of 43.1% to 29.03% in 2021, representing a reduction of 14 percentage points. As a result, the difference between non-renewable resource consumption and electricity consumption in 2021 was just 1.34%. Furthermore, renewable resources accounted for 1/4 of the total energy consumption during that period. In other words, Finland has improved its environmental indicators in the most recent period.

## II.6 ICELAND AND ELECTRIC ENERGY

In the case of Iceland, being an island makes it particularly interesting as it could serve as a benchmark for other regions or cities of similar size in terms of population and wealth creation.

It is worth noting that Iceland's reliance on natural resources has been sustained over time, even though production in terms of GWh has grown substantially.

Considering the island's energy needs, they are met by approximately 51% through electricity, and it's even better because this electricity is obtained from 100% sustainable resources, placing Iceland first worldwide, even ahead of Norway.

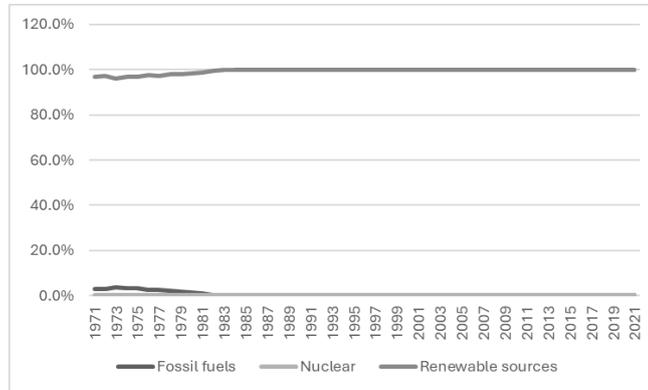


Figure 23. Contribution to total electricity production in Iceland. Based on data provided by IEA [7].

This country shows indicators that notably surpass the rest of the world, relying 100% on natural resources for electricity production, as shown in Figure 23.

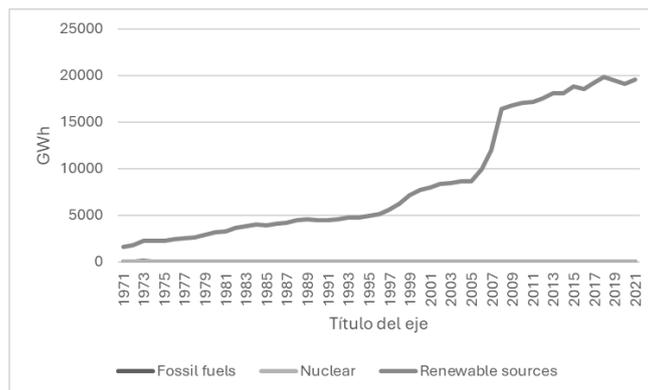


Figure 24. Iceland's trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

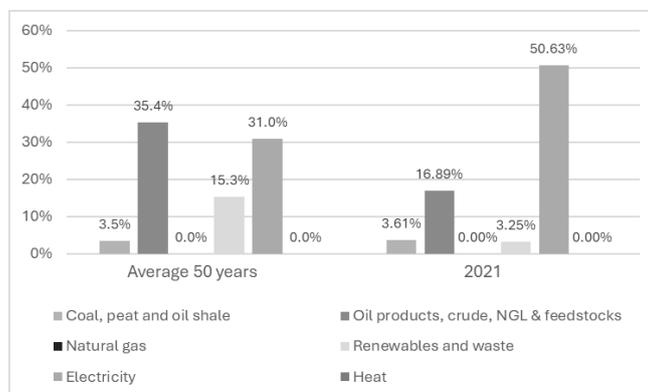


Figure 25. Contribution to total consumption in Iceland (PJ). Based on data provided by IEA [7].

## II.16 KENYA AND ELECTRIC ENERGY

Except for the year 2000, Kenya has produced electric energy primarily by utilizing sustainable resources, as can be seen in Figure 26.

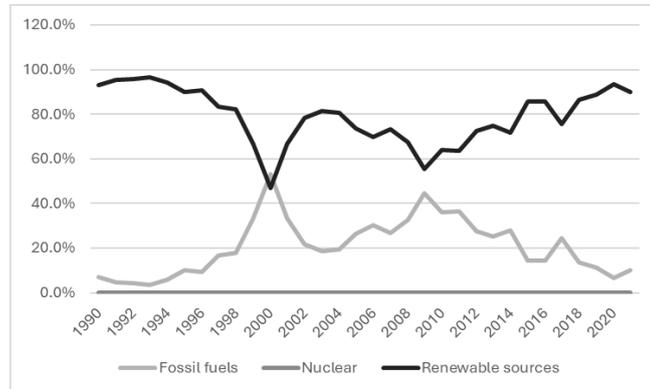


Figure 26. Contribution to total electricity production in Kenya. Based on data provided by IEA [7].

Fossil fuels supplement the input requirements since nuclear energy is not used. Additionally, there is a noticeable downward trend starting from 2010, as can be appreciated in Figures 26 and 27.

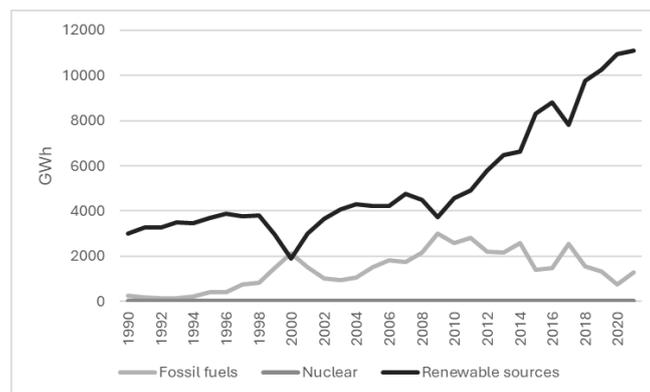


Figure 27. Kenya trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Considering the early decades of this century, the volume of energy produced from renewable resources in Kenya is ascending and substantial, which is good news for the environment.

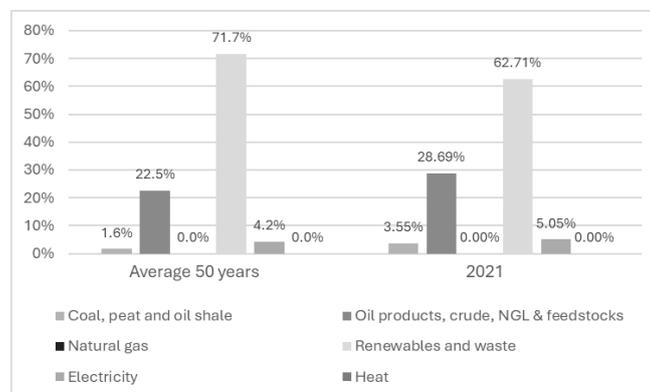


Figure 28. Contribution to total consumption in Kenya (PJ). Based on data provided by IEA [7].

In Kenya, it is surprising that the main energy source is the use of renewable resources, unlike the other analyzed countries. In a distant second place are fossil fuels, followed by electricity. Nevertheless, when comparing the analyzed average with the year 2021, there is a noticeable increase of 6 basis points in fossil

resources and a 9% reduction in the consumption of renewable resources. Overall, the country relies on wind, solar, geothermal, and hydroelectric energy [9], which is also a situation that needs to be explored in greater depth in future research.

## II.7 LATVIA AND ELECTRIC ENERGY

Throughout the study period, Latvia has relied significantly on sustainable resources for electricity production; however, the gap is closing with inputs from fossil sources, and there are even periods when they coincide.

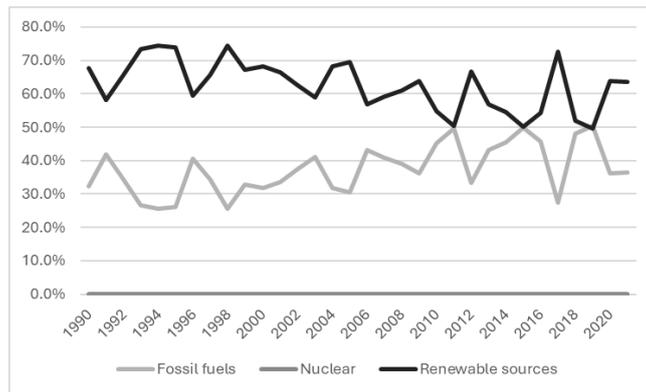


Figure 29. Contribution to total electricity production in Latvia. Based on data provided by IEA [7].

As with Iceland, Costa Rica, and other previously analyzed countries, Lithuania does not use nuclear energy to obtain electricity.

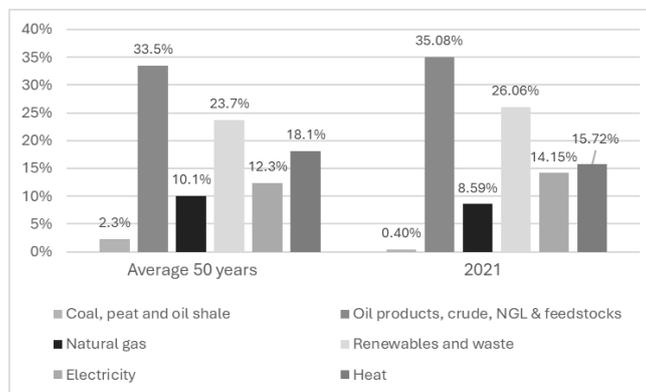


Figure 30. Latvia trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Analyzing Figure 30 confirms that renewable resources are the primary input during the observed period, with levels tending towards horizontal long-term stability.

In Latvia, electricity ranks third for both the calculated average and for 2021 in meeting consumption needs, placing the use of fuels from renewable resources in second place; however, non-renewable resources are at the forefront.

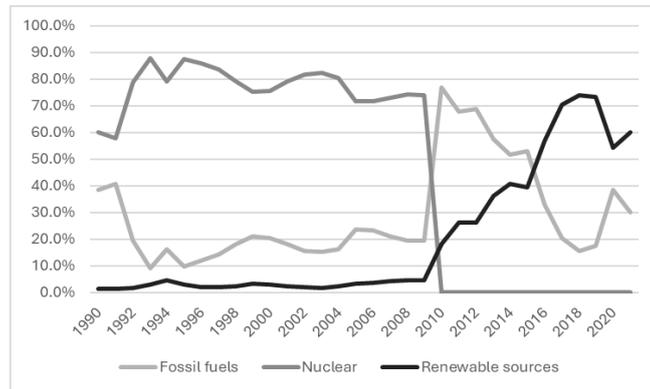


Figure 31. Contribution to total consumption in Latvia (PJ). Based on data provided by IEA [7].

## II.8 LITHUANIA AND ELECTRIC ENERGY

In Lithuania, nuclear energy played a significant role from the 1990s until the early years of this century, after which it sharply declined starting in the second decade.

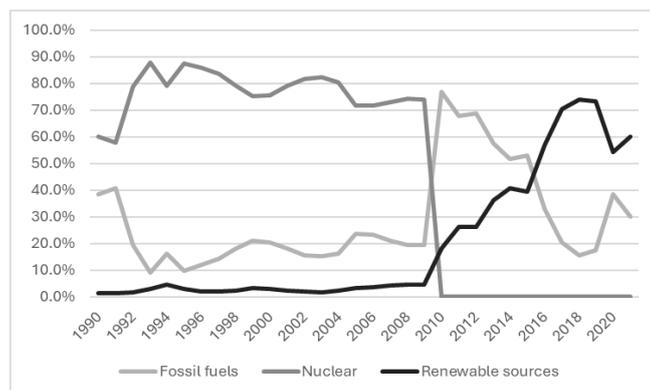


Figure 32. Contribution to total electricity production in Lithuania. Based on data provided by IEA [7].

For the second decade of this century, renewable resources are the most relevant input, surpassing fossil fuels, as shown in Figure 32.

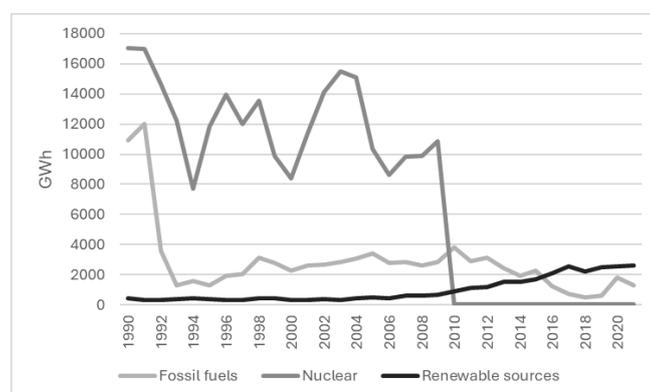


Figure 33. Lithuania trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Observing the volume trend confirms the importance of nuclear energy and its abrupt decline starting in the second decade of this century (World Nuclear Association, 2024) [10], a few years after its incorporation into the European Union (2004). It is also noteworthy that although nuclear energy

production seemed quite significant, in terms of volume, it does not appear to have been replaced by fossil fuels or by the most relevant resources to date, such as sustainable resources.

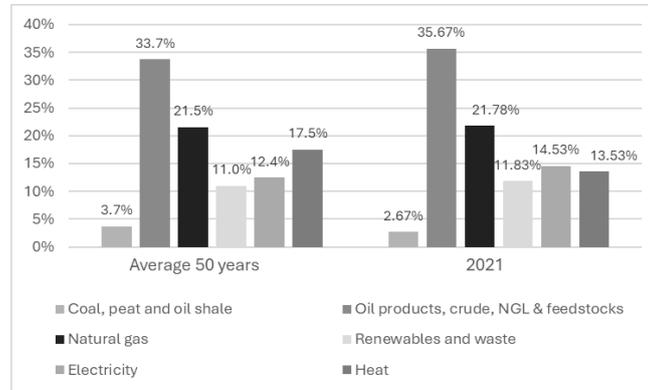


Figure 34. Contribution to total consumption in Lithuania (PJ). Based on data provided by IEA [7].

In Lithuania, fossil fuels cover more than half of the energy consumption requirements, leaving electricity in second place with only 15% of the total for 2021.

## II.9 LUXEMBOURG AND ELECTRIC ENERGY

Starting in the second decade of this century, Luxembourg changed the input relationship in electricity production, as shown in Figure 35.

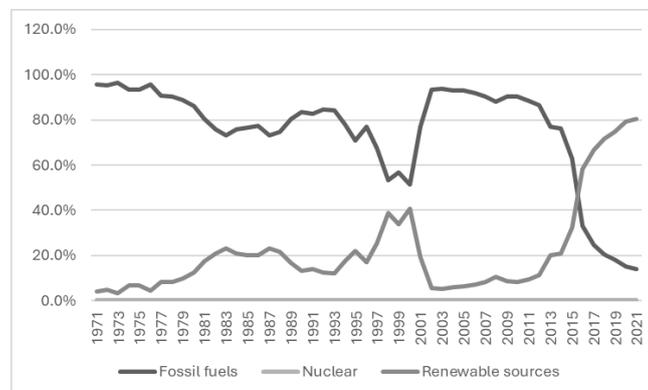


Figure 35. Contribution to total electricity production in Luxembourg. Based on data provided by IEA [7].

In Luxembourg, the use of fossil fuels had predominated as the main source for generating electric energy, a situation that has reversed since this decade; however, the trend changed starting in 2009. It is striking that after the formalization of the Kyoto Protocol in December (1997), the use of fossil fuels increased instead of decreasing [11]. The change in trend seems to be a result of The National Plan for Sustainable Development of 1998, which established specific goals for 2010 to increase the use of renewable resources for electricity generation [12] [13]. Although by the time the European Green Deal [14] was formalized (2019), the trend had already reversed in favor of sustainable resources.

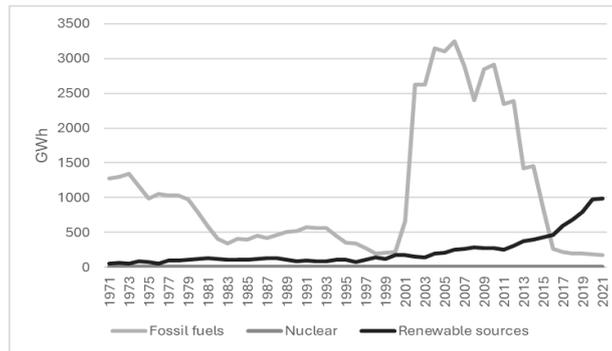


Figure 36. Luxembourg trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

In Figure 36, the use of fossil fuels is highlighted, which significantly increased in the first decade of this century; however, the trend changes in the second decade, coinciding with the formalization of the Paris Agreement (2015) and its adoption (2016).

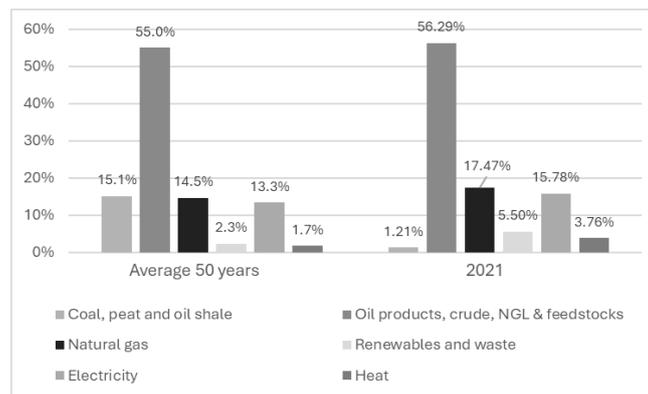


Figure 37. Contribution to total consumption in Luxembourg (PJ). Based on data provided by IEA [7].

In Luxembourg, fossil fuels cover nearly three-quarters of total energy needs in 2021, above the historical average observed, leaving electricity in second place with about 16%.

## II.10 NEW ZEALAND AND ELECTRIC ENERGY

Once again, New Zealand is a country that, since the beginning of the study period, generates electricity largely with sustainable resources.

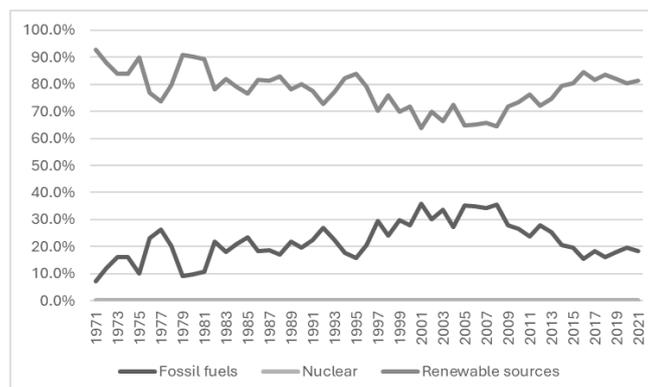


Figure 38. Contribution to total electricity production in New Zealand. Based on data provided by IEA [7].

In New Zealand, fossil fuels during the evaluation period have shown an upward trend until the second decade of this century, representing one-fifth of the total.

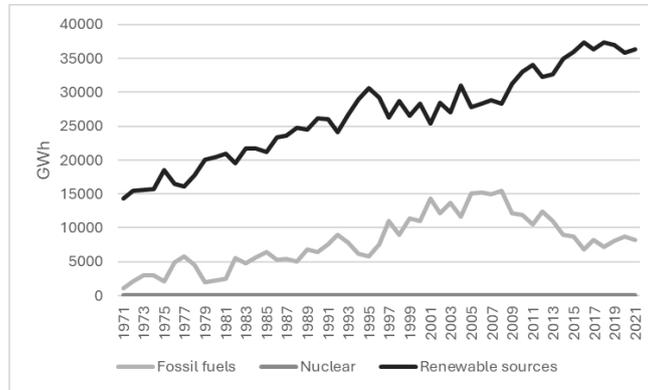


Figure 39. New Zealand trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Regarding the observed participation based on the volume of electricity generated, the growth of both renewable and fossil resource use is notable until the second decade of this century, when the latter's contribution decreases. Just for reference, nearly half of the electricity produced is allocated to industry [15], and for its generation, New Zealand utilizes hydraulic, geothermal, wind, and bioenergy [16].

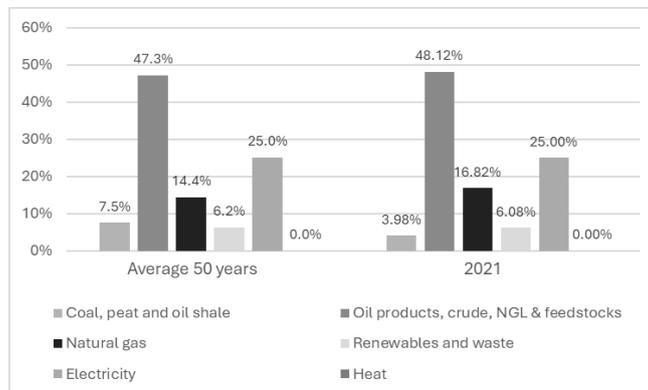


Figure 40. Contribution to total consumption in New Zealand (PJ). Based on data provided by IEA [7].

For New Zealand, the consumption of fossil resources is very relevant to meet its energy needs, while electricity has maintained a contribution of 25% over time concerning the total.

## II.11 NORWAY AND ELECTRIC ENERGY

Iceland, along with Costa Rica and Norway, leads the world in the use of sustainable resources for electricity generation.

A nearly horizontal trend close to 100% in the contribution of renewable resources is also noteworthy, with a barely perceptible share of fossil fuels and none related to nuclear energy.

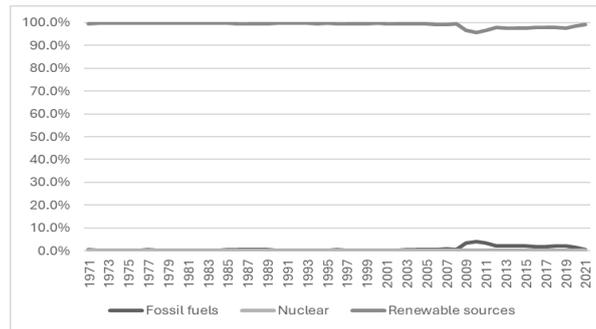


Figure 41. Contribution to total electricity production in New Zealand. Based on data provided by IEA [7].

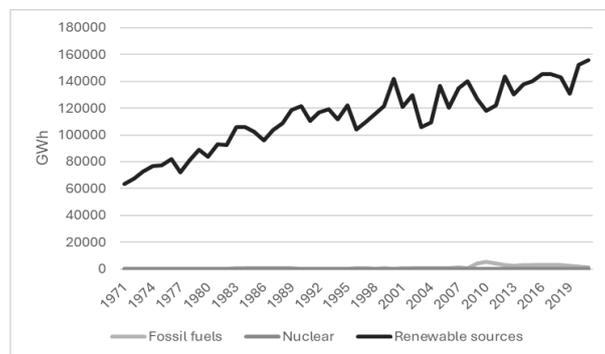


Figure 42. Norway trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Over time, there is a steady growth in the use of renewable resources, which, despite the positive slope, does not seem to require significant reliance on other sources.

In continental Europe, Norway is the most important producer of hydroelectric energy, which in turn is the primary support of the electrical system [17].

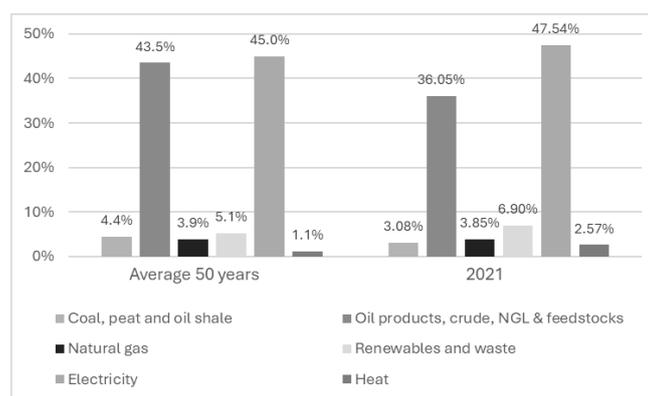


Figure 43. Contribution to total consumption in Norway (PJ). Based on data provided by IEA [7].

Regarding consumption requirements, the average result shown for Norway indicates a level slightly above the use of fossil resources compared to electricity, according to Figure 43. However, it is notable how the primary consumption shifted to electricity in 2021, which is relevant compared to what occurs in most countries around the world.

## II.12 PORTUGAL AND ELECTRIC ENERGY

The trend in the use of sustainable and non-renewable inputs has been volatile over time, and these fluctuations can be seen in Figure 44 38.

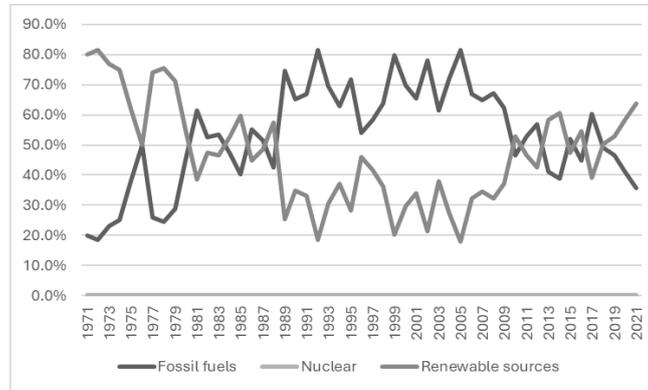


Figure 44. Contribution to total electricity production in Portugal. Based on data provided by IEA [7].

As is the case in several previously analyzed countries, Portugal does not use nuclear energy to generate electricity.

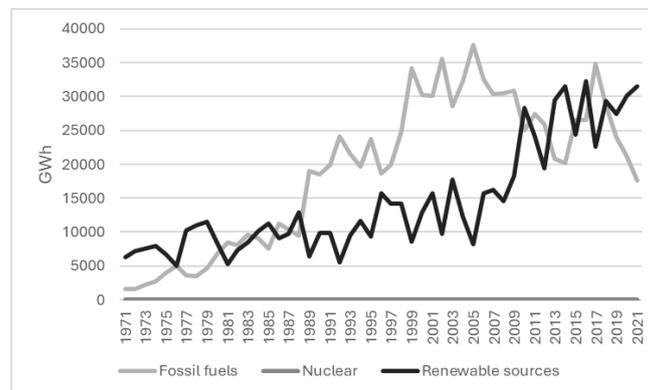


Figure 45. Portugal trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

Considering the volume of electricity produced in GWh, an upward trend is shown, and over a period of almost a quarter of a century, the use of fossil fuels predominates, with an apparent change in trend at the end of the observed period, where a decline for the latter is evident.

Almost 90% of electricity production comes from hydropower, wind, and solar energy, which reflects renewable resources [18].

In Portugal, the consumption of fossil fuels as an energy source is higher than others, but there is a reduction of 15 basis points when considering the average of the study period against the year 2021, while electricity consumption increases by nearly 7%.

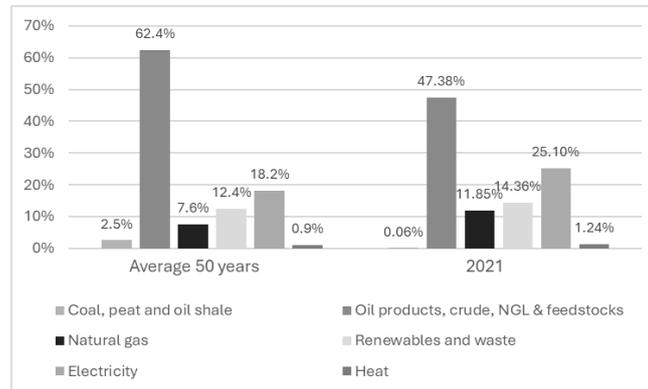


Figure 46. Contribution to total consumption in Portugal. Based on data provided by IEA [7].

### II.13 SWEDEN AND ELECTRIC ENERGY

In Sweden, a different behavior is observed compared to most analyzed countries, given that the use of nuclear energy to produce electricity is significant.

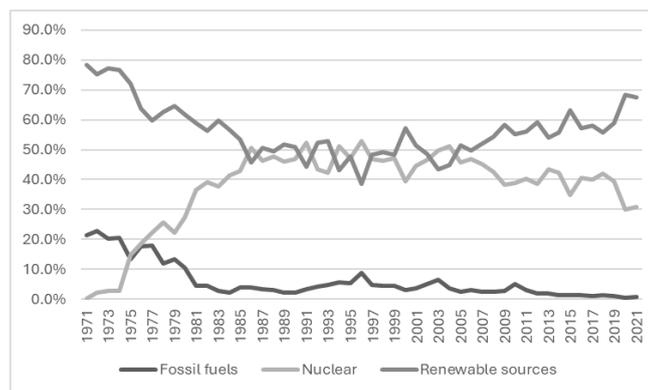


Figure 47. Contribution to total electricity production in Sweden. Based on data provided by IEA [7].

At the beginning of the observed period, the use of renewable resources is fundamental, then declines and approaches the levels of nuclear energy, only to regain prominence for sustainable resources once again.

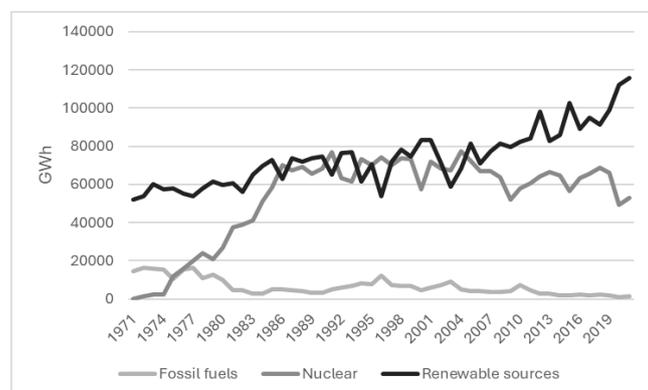


Figure 48. Sweden trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

In Sweden, fossil fuels show an insignificant contribution during the analyzed period, highlighting the use of nuclear energy and renewable resources in terms of volume measured in GWh, although at the end of the observed period, the latter dominate.

Renewable electricity is primarily obtained from hydropower and biomass by taking advantage of the country's extensive forest areas [19].

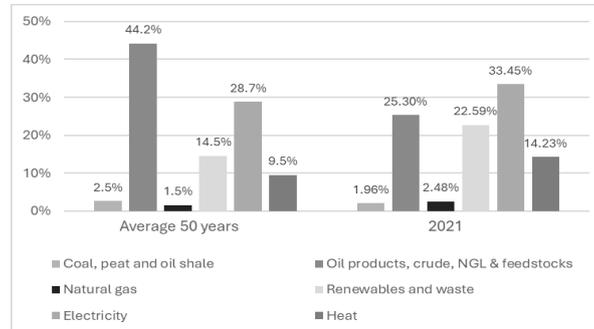


Figure 49. Contribution to total consumption in Sweden (PJ). Based on data provided by IEA [7].

In Sweden, a notable reduction in fossil fuel consumption is observed in the average calculated during the study period, compared to what is shown in 2021, when electricity consumption becomes more significant than the rest, as seen with Iceland and Norway. The growth in the use of renewable resources in 2021 is also notable, with an increase of 8% compared to the average observation.

## II.14 SWITZERLAND AND ELECTRIC ENERGY

Switzerland has historically shown a preponderance of sustainable resources over time, with nuclear energy in second place in the electricity production process.

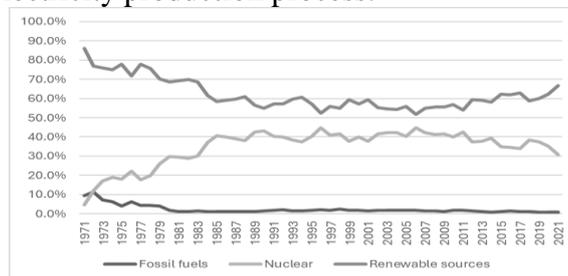


Figure 50. Contribution to total electricity production in Switzerland. Based on data provided by IEA [7].

According to Figure 50, fossil fuels are not a relevant option for electricity generation during the analyzed period, unlike many countries worldwide.

In terms of volume, there is a growing trend in the two main inputs, namely sustainable resources and nuclear energy, while fossil fuels show a downward trend to become insignificant.

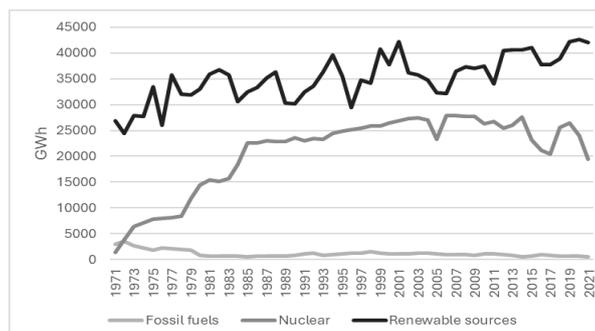


Figure 51. Switzerland trend of relevant inputs for electricity production. Based on data provided by the International Energy Agency (IEA) [7].

The most relevant renewable energy in Switzerland is hydroelectric [20], and as the sites for building new plants have reached their limit, the country needs to optimize existing ones. Biogas, wind, and solar energy are less relevant, although the latter is on the rise. Notably, the construction of the world's first floating solar power plant in 2019, placed over a dam at an altitude of over 1800 meters above sea level, has faced challenges related to winds, water levels, and snow accumulation [21].

The plant is in Lac des Toules, within the municipality of Bourg Saint Pierre. The panels also capture the light reflected by the water and snow, a topic that will be interesting to delve into in future research.

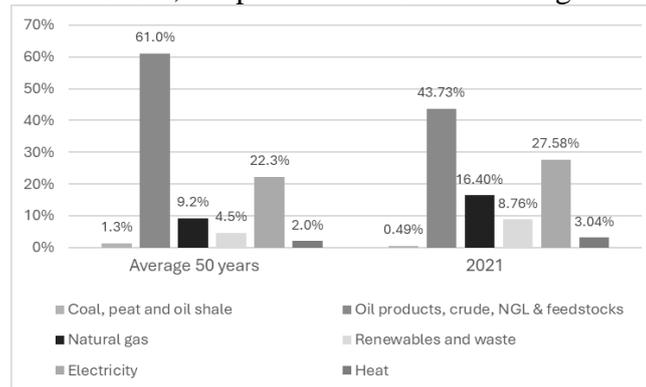


Figure 52. Contribution to total consumption in Switzerland (PJ). Based on data provided by IEA [7].

Switzerland primarily consumes fossil resources as an energy source, followed by electricity. However, the former shows a reduction for 2021 compared to the observed average.

## II.17 GROUPED RESULTS

To summarize, in all analyzed countries, the primary input used in electricity generation comes from sustainable resources, which is why they were selected.

To gain a better perspective, Table 1 presents the contribution of each relevant input from the selected countries for electricity production in 2021.

Table 1 Electricity output (GWh) in 2021. Based on data provided by IEA [7].

Country	Continent	Fossil fuels	Nuclear	Renewable sources
Austria	Europe	20%	0%	80%
Brazil	America	20%	2%	77%
Canada	America	18%	14%	67%
Colombia	America	25%	0%	75%
Costa Rica	America	0%	0%	100%
Finlandia	Europe	13%	33%	54%
Iceland	Europe	0%	0%	100%
Kenya	Africa	10%	0%	90%
Latvia	Europe	36%	0%	64%
Lithuania	Europe	33%	0%	67%
Luxembourg	Europe	15%	0%	85%
New Zealand	Oceania	18%	0%	82%
Norway	Europe	1%	0%	99%
Portugal	Europe	36%	0%	64%
Sweden	Europe	1%	31%	68%
Switzerland	Europe	1%	31%	68%

Ten of the 15 countries did not use nuclear energy in 2021 as a source of electricity generation. Only Iceland and Costa Rica use 100% renewable resources to produce electricity, although Norway reaches 99%.

None of the countries identified exceed a 36% contribution from fossil fuels in electricity production.

Table 2. GDP by country [22].  
GDP Current US\$ (2023)

Country	Trillions	Contribution
	\$	
Austria	0.52	0.5%
	\$	
Brazil	2.18	2.1%
	\$	
Canada	2.14	2.0%
	\$	
Colombia	0.36	0.3%
	\$	
Costa Rica	0.09	0.1%
	\$	
Finlandia	0.30	0.3%
	\$	
Iceland	0.03	0.0%
	\$	
Kenya	0.11	0.1%
	\$	
Latvia	0.04	0.0%
	\$	
Lithuania	0.08	0.1%
	\$	
Luxembourg	0.09	0.1%
	\$	
New Zealand	0.25	0.2%
	\$	
Norway	0.49	0.5%
	\$	
Portugal	0.29	0.3%
	\$	
Sweden	0.59	0.6%
	\$	
Switzerland	0.01	0.0%
	\$	
Sum	7.56	7.2%
	\$	
World	105.44	100.0%

Only Finland, Switzerland, and Sweden depend on one-third of nuclear energy for electricity

production.

As a reference, the 16 selected countries collectively contribute 7.2% of the global Gross Domestic Product (GDP), according to data from the World Bank.

## II. CONCLUSIONS

The production of electricity worldwide primarily relies on fossil fuels, followed by renewable resources, and then nuclear energy.

According to the data provided by the International Energy Agency (IEA), only 16 nations in the world go against the global average, meaning they primarily use sustainable resources to generate electricity.

Among the observed countries, only Iceland, Norway, and Sweden meet their total energy requirements through electricity usage.

Kenya is the only country that meets its consumption needs with renewable resources, significantly overshadowing fossil fuels and electrical energy.

The 16 countries producing electricity from sustainable resources contribute 7% to the global GDP.

To consider electricity as clean energy, it is essential to account for renewable resources; however, attention must also be paid to the portion that corresponds to the use of fossil fuels. Otherwise, promoting their consumption will also encourage them. This has a direct impact on industry in general and transportation, including the use of electric cars.

Based on the results obtained, it is important to continue researching successful policies and strategies in each of the analyzed countries.

Further investigation into the consequences for Lithuania after it ceased using nuclear energy following the closure of the Ignalina plant in 2009, after its accession to the European Union in 2004, is necessary. This includes examining how they have navigated this situation, its environmental impacts, and the cost-benefit relationship.

Continuing the analysis by countries of interest, specifically regarding the Nordic region, given their progress in environmental matters, is also advisable.

It is essential to evaluate the situation concerning the 12 most significant economies in the world in relation to the use of renewable resources.

This includes the situation in North America, where Canada, the United States, and Mexico collectively contribute one-third of the global gross domestic product.

A thorough analysis is also necessary for countries with significant advancements in using clean energy to meet their consumption needs, such as Iceland and Norway, from the production perspective, supported by sustainable resources, as reference elements for other cities and countries.

In each case, it is advisable to analyze the level of dependency on imports or the capacity to export electricity.

It is important to continue studying the factors that have led Kenya to primarily sustain its energy needs through sustainable resources.

Expanding research on this topic concerning nations with greater contributions to global wealth is necessary.

Furthermore, the research potential extends to efforts made in the selected countries for the development of energy derived from hydroelectric sources, wind, and solar energy, as exemplified by the floating plant in Lac des Toules, Switzerland, among others.

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