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Energy Consumption Trends before and during the Covid-19 Pandemic: An Entropy-Based PROMETHEE Analysis

Covid-19 Pandemisi Öncesi ve Sırasındaki Enerji Tüketim Trendleri: Entropi Tabanlı PROMETHEE Analizi

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Abstract

Renewable energy sources have a crucial role in decreasing reliance on fossil fuels. In the literature, there is a need for new studies on the evaluation of energy use preferences and policies of countries before and during the Covid-19 pandemic. In order to fill this gap, the study aimed to compare and evaluate 36 countries through Entropy-based PROMETHEE methods using TheGlobalEconomy.com indicators. As a result of Entropy, while the criterion with the highest importance is the gasoline consumption criterion with a value of 14.12%, the criterion that follows these criteria in order are the fossil fuels electricity generation (12.25%); coal consumption (11.8%); coal imports (10.52%); renewable power generation (10.29%). According to the PROMETHEE results, Sweden ranked first and is a good performer in almost all the indicators. In addition, the first 10 countries in the ranking are the European Union countries. The novelty of the study is that it provides an important review of the current literature on energy and that 36 countries with significant economic power from almost all continents are evaluated in terms of energy consumption and preferences at both pre-pandemic and pandemic conditions.

Keywords: Renewable Energy, Environmental Management, Entropy, PROMETHEE, Covid-19.

Öz

Yenilenebilir enerji kaynakları, fosil yakıtlara olan bağımlılığın azaltılmasında önemli bir role sahiptir. Literatürde Covid-19 pandemisi öncesi ve sırasında ülkelerin enerji kullanım tercihleri ve politikalarının değerlendirilmesine yönelik yeni çalışmalara ihtiyaç duyulmaktadır. Bu boşluğu doldurmak için çalışma, TheGlobalEconomy.com göstergelerini kullanarak Entropi tabanlı PROMETHEE yöntemleriyle 36 ülkeyi karşılaştırmayı ve değerlendirmeyi amaçlamıştır. Entropi sonucunda en yüksek öneme sahip kriter %14,12 değeri ile benzin tüketim kriteri iken, bu kriterleri sırasıyla takip eden kriter fosil yakıtlardan elektrik üretimi (%12,25); kömür tüketimi (%11,8); kömür ithalatı (%10.52); yenilenebilir enerji üretimi (%10,29). PROMETHEE sonuçlarına göre İsveç ilk sırada yer almaktadır ve hemen hemen tüm göstergelerde iyi bir performans sergilmektedir. Ayrıca, sıralamada ilk 10 ülke Avrupa Birliği ülkelerinden oluşmaktadır. Çalışmanın literatüre sunduğu yenilik, güncel enerji literatürüne önemli bir inceleme sunması ve hemen hemen tüm kıtalardan önemli ekonomik güce sahip 36 ülkenin hem pandemi öncesi hem de pandemi koşullarında enerji tüketimi ve tercihleri açısından değerlendirilmesidir.

Anahtar Kelimeler: Yenilenebilir Enerji, Çevre Yönetimi, Entropi, PROMETHEE, Covid-19.

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Introduction

According to the International Energy Agency (IEA)'s "major slight" plan for zero-carbon energy sources, wind and solar power will account for 40% of global energy production. TThe COVID-19 pandemic lockdown has had a tremendous impact on the environment. As demonstrated in Table 1, air quality has improved as a result of significant reductions in carbon dioxide and nitrogen oxide emissions, as well as an increase in related ozone (O3), as compared to 2019 levels for the same time period (Rita et al., 2021).

Table 1

COVID-19 Lockdown Period Emission Reductions for the Years 2019–2020

Sn	Emission	% Reduction/increase
1	CO_2	25↓
2	NO	30↓
3	O_3	30↑

↓- decrease, ↑-increase.

Today, fossil fuels provide 80 percent of global energy. Despite this superiority of fossil fuels in terms of global energy supply, rising air pollution in wealthy industrial nations, the negative implications of global warming, and the desire to reduce reliance on foreign energy sources have raised interest in renewable energy sources. Renewable energy sources are crucial for decreasing reliance on fossil fuels like coal, oil, and natural gas. When global energy output is compared across various energy sources, the renewable energy sector has had the largest yearly average rise over the previous fifty years. As a result of this interest, the yearly average rise in renewable energy supply has been around five times that of other energy sources during the previous fifty years. Globally, energy generated from renewable energy sources other than hydro and biofuels increased by 9.4 percent each year throughout this time. Considering that the annual average increase in the energy produced from oil in the same period was only 1.2 percent, it is clear that renewable resources, especially wind and solar, have been increasingly used in energy production. When the last 40-year period is compared, coal production in Europe decreased by 52.5 percent, while in North America the decrease was 11.2 percent and the Commonwealth of Independent States, including Russia (CIS: Azerbaijan, Belarus, Armenia, Kazakhstan, Kyrgyzstan, Moldova, Uzbekistan, Russia and Tajikistan) was 27.2 percent. The Commonwealth of Independent States and North America are locations abundant in alternative fossil fuels. Therefore, this had a much greater effect on this reduction than environmental awareness. While coal production decreased in the West and Russia over the same era, it increased significantly in the Asia-Pacific area (Enerdata, 2020; IEA, 2020; Looney, 2020).

The worldwide recession in the energy industry has resulted in considerable revenue losses for the majority of energy corporations. Due to poor demand and low pricing for its goods, including oil, gas, coal, and power, the energy industry has been suffering a double loss. The average price of oil decreased dramatically. For the first time in history, West Texas Intermediate prices fell below zero. LNG prices in the European and Asian markets fell to all-time lows. Natural gas prices fell negative in the United States, where storage space was full. Coal suffered less damage as its supply chain was less affected by logistical constraints than oil and gas. The combination of low-cost gas and declining demand has resulted in a one-third fall in wholesale energy costs. Market prices for electricity fell below zero in the United States and some countries in Europe, including Belgium, Denmark, Finland, France, Germany, Sweden and Switzerland (IEA, 2020).

The rapid recovery above the expectations behind the contraction in the economies due to Covid-19 increased the energy demand significantly in 2021. The inadequacy of the present energy supply to fulfill the increased energy demand resulted in considerable rises in both oil and natural gas prices. When 2022 is considered, the growth in natural gas prices in EU nations demonstrated that it will continue to be a significant component in inflation in 2022, as it was in 2021. The World Bank published the October 2021 issue of its Commodity Markets Outlook Report with the title "Urbanization and Commodity Demand". According to the report, energy costs increased in the third quarter of 2021 and are projected to continue elevated in 2022. In the report; It was noted that the energy commodity price index consisting of oil, natural gas and coal is expected to increase by 83.4 percent this year compared to last year, while the index consisting of non-energy commodity prices such as agricultural products, metals and minerals is expected to increase by 31 percent. The research claimed that although the energy commodity price index is predicted to rise by 2.3 percent next year, the non-energy commodity price index is likely to fall by 2.3 percent. In the report, it is predicted that the price of crude oil per barrel will increase by 69.7 percent compared to last year and will reach an average of $ 70, while it is expected to reach an average of $ 74 in 2022 with an increase of 5.7 percent (World Bank, 2020).

Renewable energy is energy derived from sources in the natural environment that may be accessed continuously or repetitively. Renewable energy sources include the sun, wind, biomass, geothermal, and wave energy. Renewable energy is also described as energy derived from natural resources that is environmentally sustainable. In contrast to fossil fuels, these resources are limitless throughout time and serve as a viable alternative to non-renewable energy sources such as coal, gasoline, and natural gas (Sharif et al., 2020).

Renewable energy is regarded to be the fastest expanding industry worldwide, with more finance being allocated to renewable energy projects than ever before. As the need for clean, sustainable energy increases and renewable energy technology progress, larger and more complicated projects are being constructed (aenerji, 2021). Table 2 summarizes many of them.

Table 2

The Largest and Most Expensive Renewable Energy Projects in the World

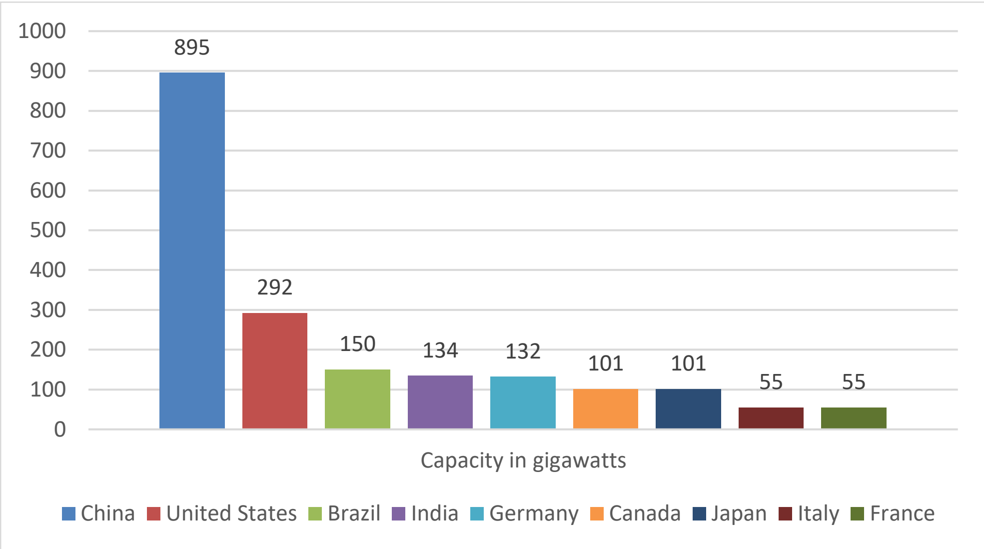
Project name and region	**Project type**	**Cost (billion dollars)**
Wudongde Hydroelectric Power Plant / China	Hydroelectric	15.4
Inga 3 / Democratic Republic of the Congo	Hydroelectric	14
Keeyask Hydroelectric Power Plant / Canada	Hydroelectric	8.7
Hornsea 2 Renewable Energy Project / United Kingdom	Offshore wind	7.8
Ghana Wave Power Project, Ghana	Wave	7.5
Ulanqab Wind Farm / China	Terrestrial wind	6.2
Triton Knoll / United Kingdom	Offshore wind	6
Leh and Kargil Solar Energy Projects / India	Solar PV	6
Mohammed bin Rashid al-Maktoum Solar Park Phase IV / Dubai	Solar CSP	4.295
Shek Kwu Chau Energy from Waste / Hong Kong	Energy from waste	4

The world's leading nations in terms of installed renewable energy capacity in 2020 are shown in Figure 1 (Statista, 2021).

Despite the pandemic, renewable energy sources are the only energy source with increased demand in 2020, while the consumption of all other fuels has decreased in usage. Highlights from the report are as follows: In 2020, annual renewable capacity additions increased by 45% to almost 280 GW – the highest annual increase since 1999. Solar PV development continued to break records, reaching 162 GW, almost 50% higher than the pre-pandemic level in 2019. Global wind capacity additions increased by more than 90% to 114 GW in 2020. While the annual market growth rate may slow in 2021 and 2022, it is still expected to be 50% above the 2017-2019 average. With more policy support and reduced PV costs, Europe's capacity growth is expected to accelerate, driven by the evolving Power purchase agreement (PPA). The updated forecast for the United States is more optimistic due to federal tax credit extensions. The new US emissions reduction targets and infrastructure proposal, if adopted, will accelerate the expansion of renewable energy beyond 2022. When 2021 is evaluated, Turkey's total installed power in renewable energy exceeded 97 thousand MW, while the share of natural gas in electricity generation decreased to 25 percent (Ernst&Young, 2020).

Figure 1

Leading Countries in Renewable Energy Capacity Installation in 2020 (in gigawatts)

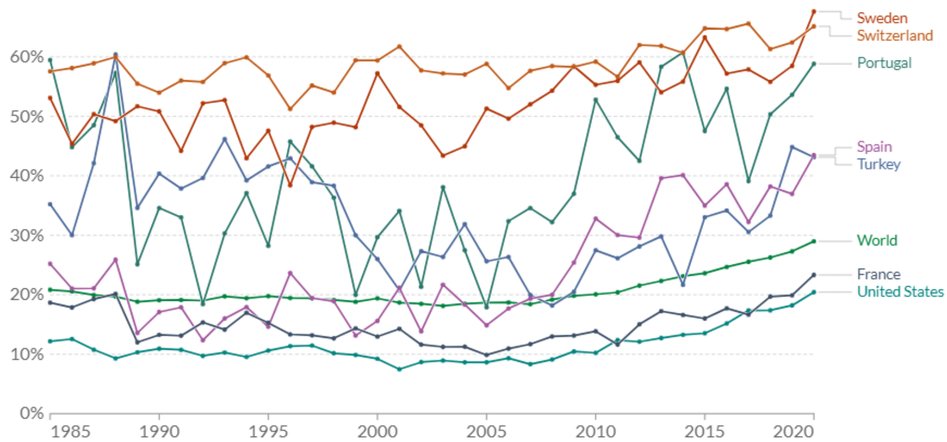


While the amount of electricity generated by renewable energy sources in Europe surpassed the amount generated by fossil fuels for the first time in 2020, Turkey also generated 50,790 MW of electricity from renewable sources, corresponding to 53.32 percent of its 97.070 MW installed power as of the end of March 2021. Turkey's total installed capacity of domestic and renewable energy reached 62,125 MW over the same time, accounting for 64% of total installed capacity. Turkey completed 2020 as the fifth largest renewable energy investor in Europe and the 12th largest globally, owing to its investments in renewable energy. The share of wind energy reached a capacity corresponding to 9.7 percent with 333 power plants (Energiewende, 2020).

The Figure 2 illustrates the percentage of power generated by renewable sources. Renewable energy sources include hydropower, solar, wind, biomass and waste, geothermal, wave, and tidal energy (Energiewende, 2020; Ritchie & Roser, 2020).

Figure 2

The Share of Electricity Production from Renewables



In the world, the installed power in renewable energy increased by 260 gigawatts in 2020, reaching a total of 2,799 gigawatts. According to the "Renewable Capacity 2021 Statistics" report of the International Renewable Energy Agency (IRENA), the increase in renewable energy capacity worldwide in 2020 was 50 percent more than in 2019. About 91 percent of green power came from wind and solar investments. During this period, 127 gigawatts of solar energy and 111 gigawatts of wind power were put into use. According to IRENA data, by 2050, renewable energy sources will meet 86% of global energy needs. This is an extremely ambitious but necessary goal for the future of the Earth (IRENA, 2021).

Considering that solar energy is the dominant source of energy on our planet, investment in this type of energy would not be surprising. The use of solar energy is expected to increase significantly in the coming years. When it comes to the distribution of solar grid-connected systems around the globe, China is the leader with its installed power exceeding 78 GW. The People's Republic of China is followed by the United States of America, Japan, and Germany. Turkey is ranked 15th in the current statistics (Güneş, 2018).

When the whole production chain is analyzed in terms of nuclear energy, which is one of the indicators used in this study, nuclear energy is the least polluting option for greenhouse gas emissions. Nuclear energy has a great role in reducing the greenhouse gas concentration in the atmosphere, which causes climate change. Today, nuclear power plants save about 17% annually in greenhouse gas emissions from the electricity sector. In other words, if fossil fuel plants were used to generate power instead of these plants, 1.2 billion tons of carbon would be emitted into the environment each year. On a global scale, 54 nuclear reactors are currently under construction. Eleven are in China, seven are in India, and four are in Russia. Additionally, the construction of 4 nuclear reactors in the United Arab Emirates, 4 in South Korea, 2 in the USA and 1 in France continues (NEUPGM, 2021; TENMAK, 2021).

In this study, MCDM methods were used to determine the evaluation and ranking of 36 countries in the global framework for renewable energy consumption and production, as well as fossil fuel consumption, for the pre- and post-pandemic (2019 and 2020) periods, and recommendations were made based on the results. As a result, the suggested entropy-based PROMETHEE technique examines the consumption and local potential of renewable energy and consumption of fossil fuels in 36 nations from all parts of the globe.

The rest of the research is organized as follows: Section 2 presents a literature review for renewable energy and decision problems. Section 3 explains all the steps of the proposed MCDM methods. Section 4 summarizes the results. Section 5 covers the discussions and Section 6 presents the conclusion.

Literature Review

The literature review on some similar studies on energy and Covid-19 that have been conducted in recent years:

Lee and Chang (2018) used four MCDM approaches (WSM, VIKOR, TOPSIS, and ELECTRE) to conduct a comparative study of renewable energy sources (RES) for power production in Taiwan. The Shannon entropy weight approach was used to determine the relative relevance of each criteria in terms of RES ranking. established a useful guideline for renewable energy planning and decision-making to assist developing nations in more successfully harnessing their plentiful renewable energy resources. They examined Iran as a case study. Ergen and NAZLIGÜL (2021) criticized Turkey and the global energy situation in 2021. Turkey and the condition of the world's energy resources were discussed in detail in this article. Countries' energy reserves, generation, and usage were highlighted. Naderipour et al. (2020) tried to demonstrate the potential benefits of COVID-19 on the environment and the growth of renewable energy production in Malaysia. Kaya (2020) examined the influence of the COVID-19 on the sustainable development of OECD nations, and the countries' sustainable development performance using the Multi-Attributive Ideal-Real Comparative Analysis (MAIRCA) technique. Data for the second quarter of 2020 and the same quarter of the previous year is considered. The findings of the MAIRCA approach were then compared to those of two distinct multi-criteria decision-making (MCDM) methods, MABAC (Multi-Attributive Border Approximation Area Comparison) and WASPAS. Hoang et al. (2021) discussed the effects of the COVID-19 pandemic on the global energy system and the development toward renewable energy. Additionally, they attempted to provide some recommendations on potential possibilities, problems, and policy implications. aimed to express concepts that would encourage policymakers and stakeholders in energy and electricity production and usage to continue environmental improvements established during the COVID-19 pandemic lockdown. This, they argued, may be accomplished by increasing investment in environmentally friendly technology and reinvigorating renewable energy policy initiatives. At COVID-19, Hosseini (2020), provided a perspective on the worldwide development of renewable and sustainable energy. According to him, effective policies may transform COVID-19's threats into tremendous possibilities for renewables, and the world's sustainable energy picture might eventually turn to its long-term trend of green energy output and usage over the next several years. Wang et al. (2021) used a hybrid methodology that combines the data envelopment analysis (DEA) Window model and the fuzzy technique for order of preference by similarity to ideal solution (FTOPSIS) to assess the renewable energy production capabilities of 42 countries. The study's objective was to provide a technique for nations to assess their renewable energy production potential in order to construct stimulus packages for a cleaner energy future, therefore expediting sustainable development.

Several studies have been undertaken using the approach employed in this study, including the following: Behzadian et al. (2010) conducted an extensive study of the literature on PROMETHEE techniques and applications. 195 articles (89.9 percent) of the 217 publications assessed were deemed appropriate for the objectives of this evaluation. The applications of PROMETHEE methodologies were many and diverse, which made it difficult for the writers to identify pertinent issues. Following a thorough examination of the applications to ascertain similarities and differences, 195 papers were classified into nine categories. The following table summarizes the number of papers and their proportion of the total that deal with each field. As seen in the Table 3, a significant portion of the PROMETHEE papers dealt with environmental management (Behzadian et al., 2010).

Table 3

Distribution of Articles according to Application Areas

Application areas	N	%
Environment Management	47	24.1
Business and Financial Management	25	12.8
Hydrology and Water Management	28	14.4
Chemistry	24	12.3
Logistics and Transportation	19	9.7
Energy Management	17	8.7
Manufacturing and Assembly	19	9.7
Social	7	3.6
Other Topics	9	4.6
Total	195	100

Land-use planning, waste management, Life Cycle Assessment (LCA), and Environmental Impact Assessment (EIA) are just a few of the many dimensions of Environmental Management that have been studied. For the issue of Energy Management, a number of PROMETHEE applications are recommended. Most studies in this field have focused on analyzing and choosing energy generating or exploitation options.

The PROMETHEE method's findings may be represented graphically using the GAIA plane, another descriptive tool. Additionally, this tool is a helpful resource for analyzing conflicts between criteria and resolving the issue of the weights associated with them (Mareschal & Brans, 1988). The GAIA plane is the outcome of Principal Component Analysis (PCA), which preserves the maximum amount of information possible after projection (Brans & Mareschal, 2005). The GAIA plane concept is based on the reduction of multidimensional issues to two dimensions, hence enabling direct presentation. The PCA is an extremely useful tool for the decision-maker since it allows them to distinguish between criteria expressing similar or opposing preferences, as well as the quality of each choice based on the various criteria (Behzadian et al., 2010).

After reviewing the literature on the PROMETHEE approach, it was agreed that the analyzing method for the study would be PROMETHEE and GAIA. Countries might be compared in terms of sustainable environment and energy management, as well as renewable energy consumption. Several comparable studies conducted in recent years are as follows:

Tsiaras and Andreopoulou (2020) used a multiple-criteria analysis of forestry sector data gathered by Eurostat to assess the performance of European nations' forest policies. According to that research, Multiple Criteria Decision Analysis is inextricably linked to policy and decision-making, and it may help decrease planning uncertainty by proposing concrete answers. It is also often used to address environmental challenges. The PROMETHEE technique was used to rank European nations on the basis of their forest policy performance. Digkoglou and Papathanasiou (2018) employed PROMETHEE to evaluate the EU nations according to their environmental performance. Guler et al. (2021)used PROMETHEE to assess the sustainability of energy in 36 OECD (Organization for Economic Cooperation and Development) nations. Phillis et al. (2021) developed a paradigm for defining and quantifying the sustainability of national energy systems in their article. The approach used the PROMETHEE approach to assess sustainability performance of 43 EU nations. R. Remeikienė et al. (2021) suggested a research technique for studying the usage of renewable energy sources, energy efficiency, and environmental factors of energy. The research ranked the EU member states through using PROMETHEE II and entropy techniques.

Methods and Data

This section describes indicator definitions and the methods used. Table 4 presents the energy and environment indicators that were utilized in the research (Economy, 2021). TheGlobalEconomy.com database was used for the values of the indicators. TheGlobalEconomy.com provides reliable data about countries on many issues such as economy, energy and environment. It provides up-to-date data for GDP, inflation, credit, interest rates, renewable energy, agriculture, infrastructure, industry, employment and many other indicators. The data series are constantly updated according to the publication dates of individual countries. They also present over 300 indicators carefully selected from many official sources such as the World Bank, International Monetary Fund, United Nations, and the World Economic Forum (Economy, 2021). Therefore, it was decided to make use of this database.

Table 4

Energy and Environment Indicators

Energy and Environmental Indicators	Definitions
Gasoline consumption, thousand barrels per day	Gasoline consumption includes the consumption of: conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline; but excludes the consumption of aviation gasoline. Volumetric data on blending components, such as oxygenates, are not counted in the data on finished motor gasoline until the blending components are blended into the gasoline.

Table 4

Energy and Environment Indicators (Continued)

Energy and Environmental Indicators	Definitions
Fossil fuels electricity generation, billion kilowatt-hours	Billion kilowatt-hours of electricity generated from fossil fuels including oil, coal, and natural gas.
Coal consumption, thousand short tons	Coal consumption includes anthracite, sub anthracite, bituminous, subbituminous, lignite, brown coal, and oil shale. It also includes net imports of metallurgical coke.
Coal imports, thousand short tons	Amount of foreign coal shipped to the country.
Wind electricity generation, billion kilowatt-hours	Billion kilowatt-hours of electricity generated from wind.
Solar electricity generation, billion kilowatt-hours	Billion kilowatt-hours of electricity generated from sunlight.
Hydroelectricity generation, billion kilowatt-hours	Hydroelectric generation excludes generation from hydroelectric pumped storage.
Nuclear power generation, billion kilowatt-hours	Nuclear electricity net generation (Net generation excludes the energy consumed by the generating units).
Geothermal electricity generation, billion kilowatt-hours	Billion kilowatt-hours of geothermal electricity generated.
Renewable power generation, billion kilowatt-hours	Total Renewables Electricity Net Generation (Net generation excludes the energy consumed by the generating units and also excludes generation from hydroelectric pumped storage)

Entropy Method and Objective Weights

It is essential to create a decision matrix in order to utilize the numerical values of Entropy indicators (Kahraman et al., 2017). Entropy, a notion introduced by Shannon and Weaver (1949) is used to estimate the relative comparison intensities of the decision-making variables (Zeleny, 2012). In spectrum analysis (Burg, 1974), language modeling (Rosenfeld, 1994), and economics (Golan et al., 1997), his technique has been used. The Entropy approach's weight calculation phases are as described in the following: (Apan et al., 2015; Lihong et al., 2008; Shemshadi et al., 2011; Wang & Lee, 2009):

1st Step: The Decision Matrix

$$\boldsymbol{X} = \begin{bmatrix} \boldsymbol{x_{11}} & \cdots & \boldsymbol{x_{1n}} \\ \vdots & \ddots & \vdots \\ \boldsymbol{x_{m1}} & \cdots & \boldsymbol{x_{mn}} \end{bmatrix} \quad (1)$$

2nd Step: A normalized decision matrix is constructed.

These indicators have been standardized based on their benefit or cost characteristics, allowing the values of variables with various units to be compared:

$$r_{ij} = x_{ij}/max_{ij}(i = 1, \dots, m; j = 1, \dots, n)$$
$$r_{ij} = x_{ij}/min_{ij}(i = 1, \dots, m; j = 1, \dots, n) \quad (2)$$

$i\ represents\ alternatives$; j = criteria; r_{ij} = normalized values;

x_{ij} = benefit values of the i. alternative for j.

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}};\ \forall_j \quad (3)$$

Pij represents normalized values, whereas a represents utility values.

3rd Step: Calculating the Entropy value

$$E_j = -k \sum_{i=1}^{m} [P_{ij} \ln P_{ij}] \, ; \forall_j \tag{4}$$

$k = entropy\ coefficient\ \{(\ln(n))^{-1}\}$**;**

$P_{ij} = normalized\ values$**;** $E_j = entropy\ value$

4th Step: Computing the (dj) uncertainty value

$$d_j = 1 - E_j;\ \forall_j \tag{5}$$

5th Step: wj weights are calculated to reflect the relative importance of j.

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j};\ \forall_j \tag{6}$$

It is calculated that the sum of these weights is 1.

$$w_1 + w_2 + w_j + \cdots + w_n = 1 \tag{7}$$

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation)

The PROMETHEE method is a multi-criteria decision making (MCDM) method that enables the analysis of the alternatives to be evaluated by using the preference functions selected according to the determined criteria. This evaluation for alternatives is obtained by making pairwise comparisons (Tolga, 2013). The PROMETHEE I method proposed by Mareschal et al. (1984) performs partial ranking, while the PROMETHEE II method performs full ranking. In addition, later Mareschal and Brans (1988) proposed the GAIA method in 1988, which supports the PROMETHEE method and provides graphical representations. The PROMETHEE method consists of 7 steps (Brans & Vincke, 1985; Dağdeviren & Erarslan, 2008; Ishizaka & Nemery, 2011):

Step 1: Decision matrix consisting of elements $w=(w_1, w_2, \ldots, w_k)$ representing the weights and A=(a, b, c,…) describing the alternatives evaluated by $c=(f_1, f_2, \ldots, f_k)$ representing k criteria .

Step 2: Normalize the decision matrix as follows:

$$R_{ij} = \frac{[X_{ij} - \min(X_{ij})]}{[\max(X_{ij}) - \min(X_{ij})]}$$
$$(i = 1, 2, \ldots, n \text{ and } j = 1, 2, \ldots, m) \tag{8}$$

where Xij represents the decision maker's assessment of the ith choice in relation to the j^{th} criteria.

Step 3: $P_j(i,i')$, the preference function, should be chosen and calculated. The PROMETHEE approach generates a preference function that describes the decision maker's preference difference for each criteria between pairs of options. There are six various forms of generalized preference functions, and each criteria may have its own function (Canedo & de Almeida, 2008). Figure 3 illustrates these preference functions (Brans & Mareschal, 2005; Brans & Vincke, 1985; Yaralıoğlu, 2010).

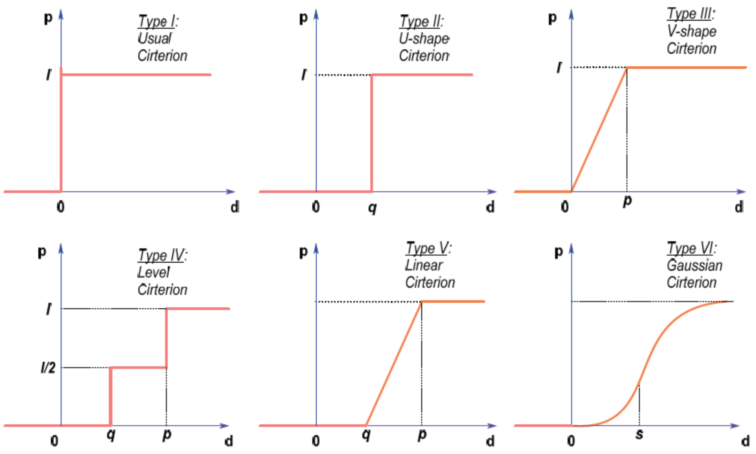
a) If there is no preference among the criteria for the decision makers, it is appropriate to choose the First Type (usual) preference function for the relevant criteria.

b) If the decision maker evaluates some criteria and wants to choose alternatives with a value above a value he deems appropriate, he should choose the Second Type (U type) preference function.

c) When the decision maker evaluates the alternatives according to some criteria, if he wants to prefer the alternatives with a value above the average value in these criteria, but does not want to ignore the alternatives with a value lower than this average value, it is appropriate to choose the Third Type (V type) preference function for these criteria.

Figure 3

Preference Functions in PROMETHEE



d) While the decision maker is evaluating the alternatives, if he/she wants to prefer value areas within a value range that he/she deems appropriate according to the criteria he/she has determined, he/she should choose the Fourth Type (level) preference function.

e) When the decision maker evaluates the alternatives according to some criteria and wants to prefer the alternatives with a value above the mean value in these criteria, it is appropriate to determine the Fifth Type (linear) preference function.

f) If the deviation values of the relevant criteria from the mean are important for the decision maker while deciding about the alternatives, the Sixth Type (Gaussian) preference function should be selected.

Step 4: Calculate the weighted aggregated preference function:

$$\pi(i,i') = \sum_{j=1}^{m} P_j(i,i')\,w_j \tag{9}$$

Where w_j denotes the j^{th} criterion's relative importance.

Step 5: Each alternative can be related to (n−1) alternatives, resulting in a positive or negative outranking flow. Thereafter, it is necessary to calculate the leaving and entering outranking flows, which are given by the following equations:

The leaving flow:

$$\phi^{+}(i) = \frac{1}{n-1}\sum_{i'=1}^{n} \pi(i,i'), \quad (i \neq i') \tag{10}$$

The entering flow:

$$\phi^{-}(i) = \frac{1}{n-1}\sum_{i'=1}^{n} \pi(i',i), \quad (i \neq i') \tag{11}$$

where n is the number of alternatives. The entering flow is a measure of the weakness of the alternatives, while the leaving flow is a measure of the strength of the alternatives.

Step 6: PROMETHEE II generates a complete preorder determined by the net outranking flow of the decision alternatives. The net outranking flow is:

$$\phi(i) = \phi^{+}(i) - \phi^{-}(i) \tag{12}$$

Step 7: Accepting or rejecting incomparability is necessary for the resolution of a given choice issue. If decision maker accepts it, he uses the PROMETHEE I, otherwise, he uses the PROMETHEE II. PROMETHEE I generally lead to a ranking of the actions by a partial pre-order since it accepts the incomparability. PROMETHEE II leads to a ranking of alternatives by a total pre-order as it does not accept the incomparability: all the alternatives are ranked from the best to the worst one.

In fact, φi can be positive or negative. The larger φi, the more xi outranks the other alternatives, the less it is outranked. Thus:

- x_i outranks x_j if and only if $\phi_i > \phi_j$
- x_i is indifferent to x_j if and only if $\phi_i = \phi_j$.

Φ+ (a) > Φ+ (b) and Φ-(a) < Φ-(b)

Decide the entire rank order of the choices (PROMETHEE II) considering the net outranking flow, φ(i). The highest φ(i) is the most acceptable option.

Results

The decision matrix used in the entropy analysis and consisting of raw values of the indicators is presented in Appendix A.

Table 5 shows the weights of the energy indicators obtained by the Entropy method. The decision matrix for the PROMETHEE study was the transformed normalized decision matrix described in Appendix B. Indicator values were normalized and converted to values in the range of 0-1. The transformation was performed with the procedure specified in the second step of the PROMETHEE methodology.

Table 5

Entropy Weights of the Energy Indicators

Indicators	Definitions	Weights
C1	Gasoline consumption, thousand barrels per day	0.1412
C2	Fossil fuels electricity generation, billion kilowatthours	0.1225
C3	Coal consumption, thousand short tons	0.118
C4	Coal imports, thousand short tons	0.1052
C5	Wind electricity generation, billion kilowatthours	0.0847
C6	Solar electricity generation, billion kilowatthours	0.0815
C7	Hydroelectricity generation, billion kilowatthours	0.0623
C8	Nuclear power generation, billion kilowatthours	0.097
C9	Geothermal electricity generation, billion kilowatthours	0.0847
C10	Renewable power generation, billion kilowatthours	0.1029

The values in the first four indicators are inverted according to the multiplication process, as is frequently used in the literature, so that the indicators that are desired to be minimum can be processed when they are specified as maximum. The study was conducted using Visual PROMETHEE, a user-friendly tool. The software is a significant multi-criteria decision support system that was developed for the purpose of implementing the PROMETHEE approach.

The research investigated both the 2019 and 2020 data for the nations in order to draw a comparison between the pre- and post-pandemic periods. Thus, it is aimed to analyze whether the values of the countries within one year affect their ranking in terms of energy criteria and to analyze their performance in both periods. As a result, the data of the countries for these two years are included in the decision matrix.

The weights used in the analysis were obtained from the Entropy analysis. In the PROMETHEE method, there are various preference functions that specify the structure and interrelationship of the evaluation criteria. These are explained in detail in the methodology section. If there is no priority for each of the criteria determining the preference for the decision makers, the first type, that is, the usual preference function, is preferred. Therefore, the preference function was determined as the first type (usual) function for all criteria, in order to make the evaluation by using only the determined Entropy weights without prioritizing certain value ranges for any criterion, regardless of subjective evaluations. Since the usual type preference function was preferred in the analysis, the values of the parameters q (indifference value), p (exact preference threshold) and s (intermediate value between p and q or standard deviation) were left blank. The parameters used in the PROMETHEE analysis are listed in Table 6.

Table 6

The Parameters of PROMETHEE Analysis for 2019-2020

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Direction of preference	max	max	max	max	max	max	max	max	max	max
Weight coefficient	0.1412	0.1225	0.118	0.1052	0.0847	0.0815	0.0623	0.097	0.0847	0.1029
Preference function	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual

The analysis's outputs and their interpretations are described later in this section. Each action is represented in the PROMETHEE Diamond by a point in the (Phi+, Phi-) plane. So that the vertical dimension (green-red axis) corresponds to Phi net flow, the plane is inclined 45 degrees. From the left to the top corner, Phi+ scores rise, whereas Phi- scores rise from the bottom to the top corner.

Each action is represented by a cone. In the PROMETHEE I Partial Ranking, overlapping cones indicate that one action is chosen over the other. Cones that intersect represent activities that cannot be compared. Using the vertical dimension, which corresponds to Phi, it is possible to see both the PROMETHEE ranks at once. Sweden'20 is definitely favored to all other activities, whereas South Korea'20 and the Netherlands'19 are incomparable, according to the findings.

PROMETHEE I provides a partial rating of nations based on energy parameters. There are three potential outcomes in terms of nations compared in this study, which includes pairwise comparisons of countries with computed positive and negative superiority values. In summation, these conceivable outcomes include a country's dominance over another, a country's indifference to another, and a country's incomparability to another. The PROMETHEE I method's partial ranking is shown in Figure 5 as the PROMETHEE Network. Each action is represented by a node in the PROMETHEE Network display, while preferences are indicated by arrows. The nodes are positioned relative to the PROMETHEE Diamond, highlighting the proximity of flow values.

In the PROMETHEE Network, Sweden’20 is clearly preferred to all the other countries, while South Korea’20 and Netherlands’19 are incomparable but very close to each other. Sweden is followed in dominance over other nations by Switzerland and Norway. For nations where the comparison findings are unclear, the PROMETHEE II approach must be used to acquire the whole ranking.

Figure 4

PROMETHEE Diamond

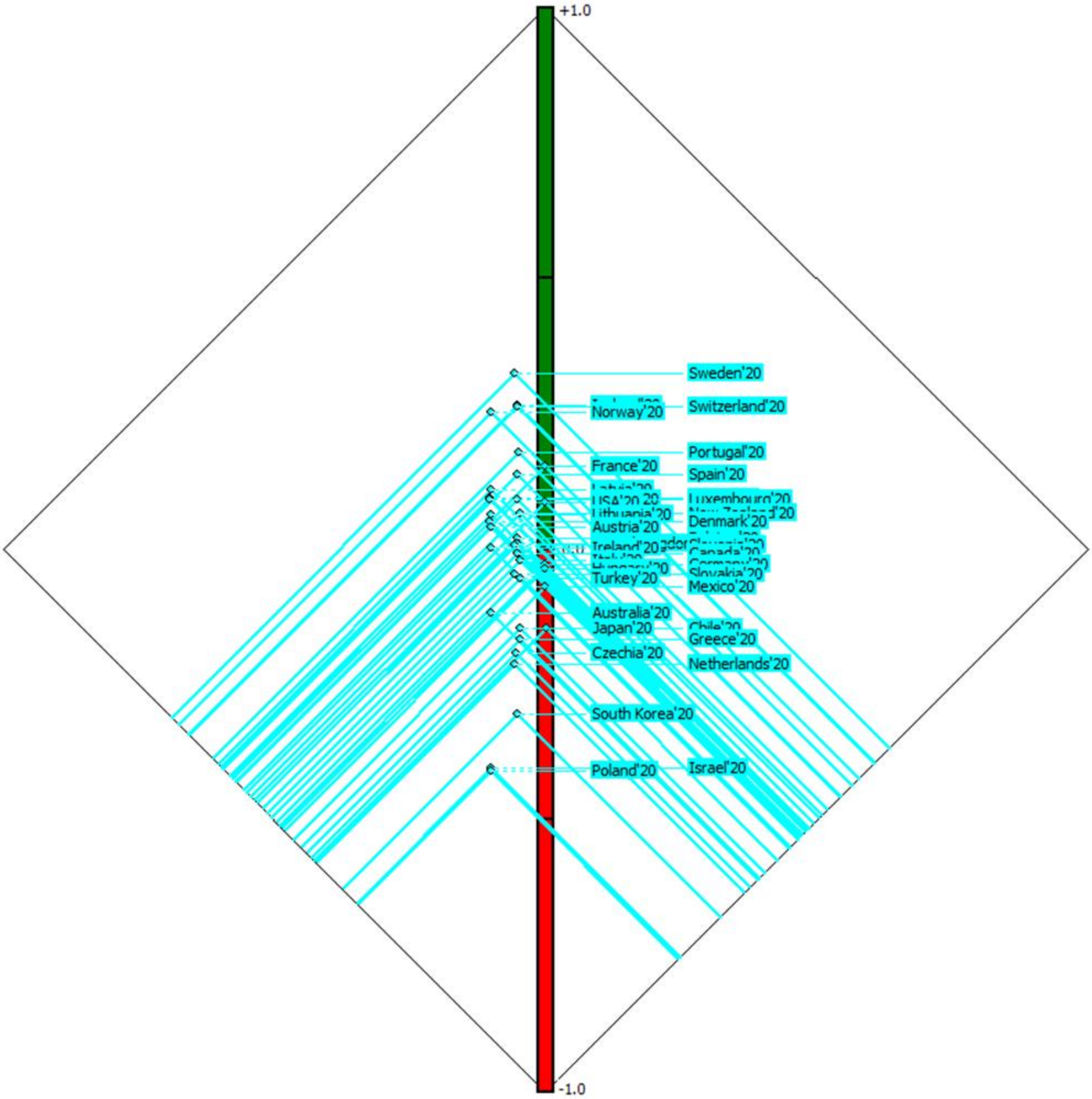
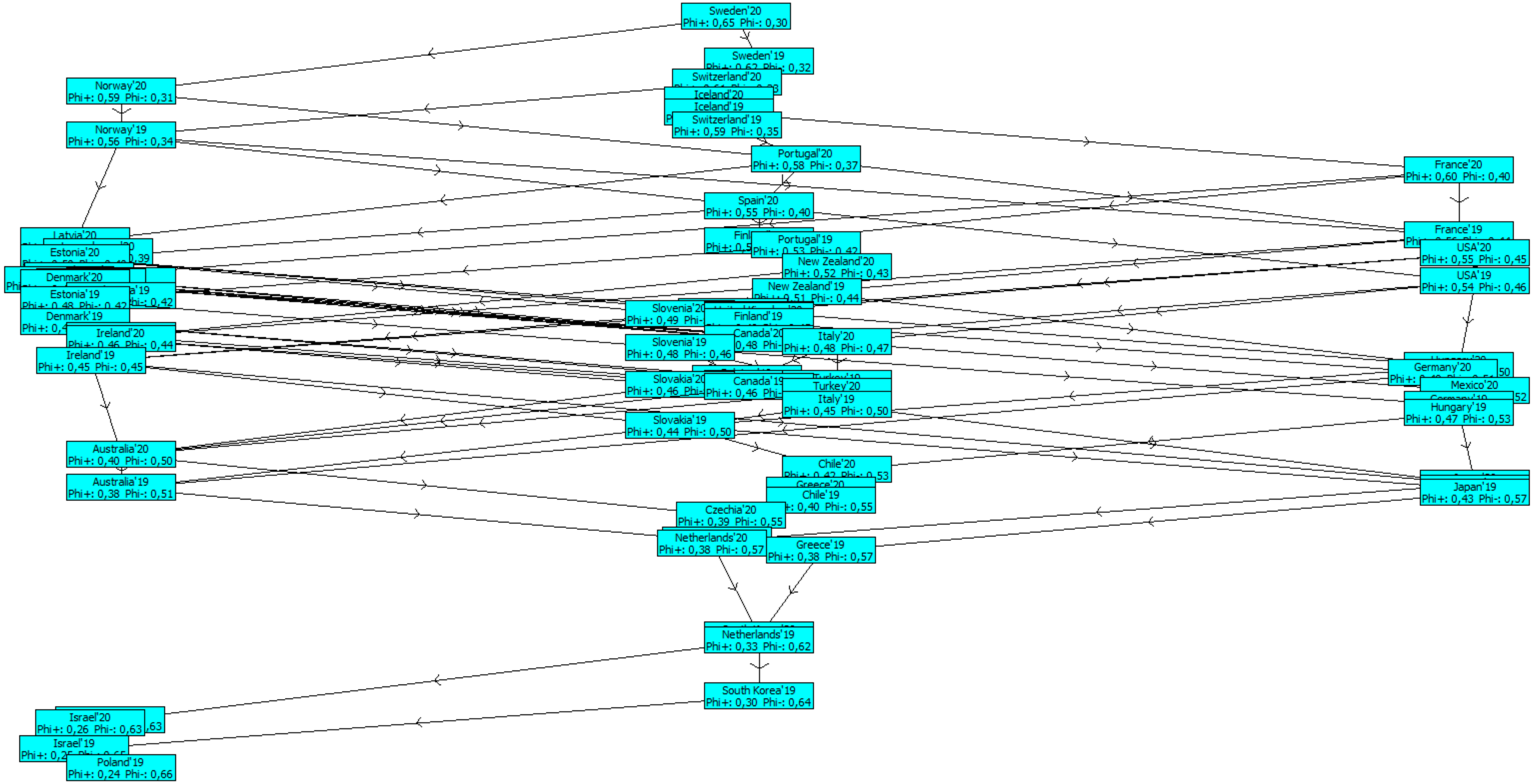


Figure 5

PROMETHEE Network



PROMETHEE II results provide a comprehensive ranking of nations, taking into consideration the net advantage value determined using negative and positive superiority values. It reaches the full rank value (Phi) by subtracting the negative superiority (Phi-) value from the positive superiority (Phi+) value. The PROMETHEE II results seen in Table 8 show the positive advantage value, negative advantage value, net advantage value and ranking of countries. Sweden, according to this research, ranks top among other nations in terms of net Phi values for both the 2019 and 2020 energy criterion. Sweden, Switzerland, Norway, Iceland, Portugal, and France are the top five nations in the list. The countries at the bottom of the ranking are Czechia, Netherlands, Greece, South Korea, Poland and Israel.

Table 7

Positive, Negative, Net Advantage Values Obtained by PROMETHEE II Analysis and Full Ranking

Rank	Action	Phi	Phi+	Phi-	Rank	Action	Phi	Phi+	Phi-
1	Sweden'20	0,3479	0,6462	0,2983	**37**	Ireland'20	0,0200	0,4593	0,4392
2	Sweden'19	0,3020	0,6241	0,3222	**38**	Italy'20	0,0166	0,4844	0,4678
3	Switzerland'20	0,2809	0,6124	0,3315	**39**	Slovenia'19	0,0114	0,4759	0,4645
4	Norway'20	0,2720	0,5853	0,3132	**40**	Ireland'19	-0,0022	0,4470	0,4492
5	Iceland'20	0,2629	0,6031	0,3402	41	Hungary'20	-0,0068	0,4960	0,5028
6	Iceland'19	0,2505	0,5969	0,3464	42	Germany'20	-0,0142	0,4917	0,5059
7	Switzerland'19	0,2368	0,5904	0,3536	43	Belgium'19	-0,0203	0,4626	0,4829
8	Norway'19	0,2274	0,5629	0,3356	44	United Kingdom'19	-0,0258	0,4603	0,4860
9	Portugal'20	0,2030	0,5764	0,3734	45	Turkey'19	-0,0260	0,4631	0,4891
10	France'20	0,1916	0,5952	0,4036	46	Slovakia'20	-0,0269	0,4567	0,4836
11	Spain'20	0,1547	0,5505	0,3958	47	Canada'19	-0,0285	0,4589	0,4874
12	France'19	0,1252	0,5620	0,4368	48	Mexico'20	-0,0329	0,4836	0,5164
13	Finland'20	0,1199	0,5331	0,4132	49	Turkey'20	-0,0333	0,4594	0,4928
14	Latvia'20	0,1194	0,5072	0,3878	50	Italy'19	-0,0464	0,4529	0,4993
15	Portugal'19	0,1156	0,5327	0,4171	51	Germany'19	-0,0473	0,4758	0,5230
16	Luxembourg'20	0,1085	0,5026	0,3942	52	Hungary'19	-0,0554	0,4717	0,5271
17	USA'20	0,1078	0,5539	0,4461	53	Slovakia'19	-0,0677	0,4363	0,5040
18	Estonia'20	0,1028	0,4989	0,3961	54	Australia'20	-0,0977	0,4004	0,4981
19	New Zealand'20	0,0930	0,5226	0,4296	55	Chile'20	-0,1128	0,4197	0,5325
20	Luxembourg'19	0,0845	0,4899	0,4054	56	Japan'20	-0,1268	0,4366	0,5634
21	Latvia'19	0,0800	0,4869	0,4069	57	Australia'19	-0,1309	0,3838	0,5147
22	USA'19	0,0791	0,5396	0,4604	58	Mexico'19	-0,1324	0,4338	0,5662
23	Austria'20	0,0790	0,4888	0,4097	59	Greece'20	-0,1343	0,4084	0,5426
24	Lithuania'20	0,0777	0,4869	0,4093	60	Japan'19	-0,1358	0,4321	0,5679
25	Denmark'20	0,0772	0,4861	0,4089	61	Chile'19	-0,1438	0,4036	0,5474
26	New Zealand'19	0,0683	0,5091	0,4408	62	Czechia'20	-0,1599	0,3922	0,5521
27	Lithuania'19	0,0634	0,4809	0,4176	63	Czechia'19	-0,1850	0,3791	0,5640
28	Estonia'19	0,0595	0,4772	0,4177	64	Netherlands'20	-0,1878	0,3775	0,5653
29	Belgium'20	0,0472	0,4958	0,4486	65	Greece'19	-0,1952	0,3779	0,5731
30	Slovenia'20	0,0457	0,4930	0,4473	66	South Korea'20	-0,2812	0,3326	0,6138
31	Spain'19	0,0446	0,4955	0,4508	67	Netherlands'19	-0,2860	0,3301	0,6162
32	United Kingdom'20	0,0434	0,4949	0,4514	68	South Korea'19	-0,3433	0,3015	0,6448
33	Finland'19	0,0375	0,4919	0,4544	69	Poland'20	-0,3674	0,2651	0,6325
34	Denmark'19	0,0371	0,4660	0,4290	70	Israel'20	-0,3700	0,2631	0,6331
35	Austria'19	0,0229	0,4607	0,4378	71	Israel'19	-0,3969	0,2490	0,6460
36	Canada'20	0,0201	0,4832	0,4631	72	Poland'19	-0,4162	0,2412	0,6573

Table 8 summarizes the performance scores derived from the PROMETHEE II study.

Table 8

PROMETHEE II Method Ranking and Scores

Countries	Score	Countries	Score	Countries	Score
Sweden '20	100	Denmark '20	56.47	Turkey '20	45.26
Sweden '19	90.24	New Zealand '19	55.48	Italy '19	44.09
Switzerland '20	86.17	Lithuania '19	54.93	Germany '19	44.01
Norway '20	84.54	Estonia '19	54.5	Hungary '19	43.3
Iceland '20	82.9	Belgium '20	53.17	Slovakia '19	42.24
Iceland '19	80.71	Slovenia '20	53.02	Australia '20	39.77
Switzerland '19	78.4	Spain '19	52.9	Chile '20	38.57
Norway '19	76.86	United Kingdom '20	52.77	Japan '20	37.49
Portugal '20	73.03	Finland '19	52.15	Australia '19	37.18
France '20	71.32	Denmark '19	52.11	Mexico '19	37.06
Spain '20	66.08	Austria '19	50.65	Greece '20	36.93
France '19	62.23	Canada '20	50.37	Japan '19	36.81
Finland '20	61.56	Ireland '20	50.36	Chile '19	36.22
Latvia '20	61.49	Italy '20	50.01	Czechia '20	35.04
Portugal '19	61.02	Slovenia '19	49.5	Czechia '19	33.28
Luxembourg '20	60.15	Ireland '19	48.17	Netherlands '20	33.08
USA '20	60.07	Hungary '20	47.73	Greece '19	32.58
Estonia '20	59.46	Germany '20	47.03	South Korea '20	27.14
New Zealand '20	58.3	Belgium '19	46.45	Netherlands '19	26.86
Luxembourg '19	57.31	United Kingdom '19	45.95	South Korea '19	23.65
Latvia '19	56.79	Turkey '19	45.93	Poland '20	22.38
USA '19	56.69	Slovakia '20	45.84	Israel '20	22.25
Austria '20	56.68	Canada '19	45.7	Israel '19	20.89
Lithuania '20	56.53	Mexico '20	45.3	Poland '19	19.94

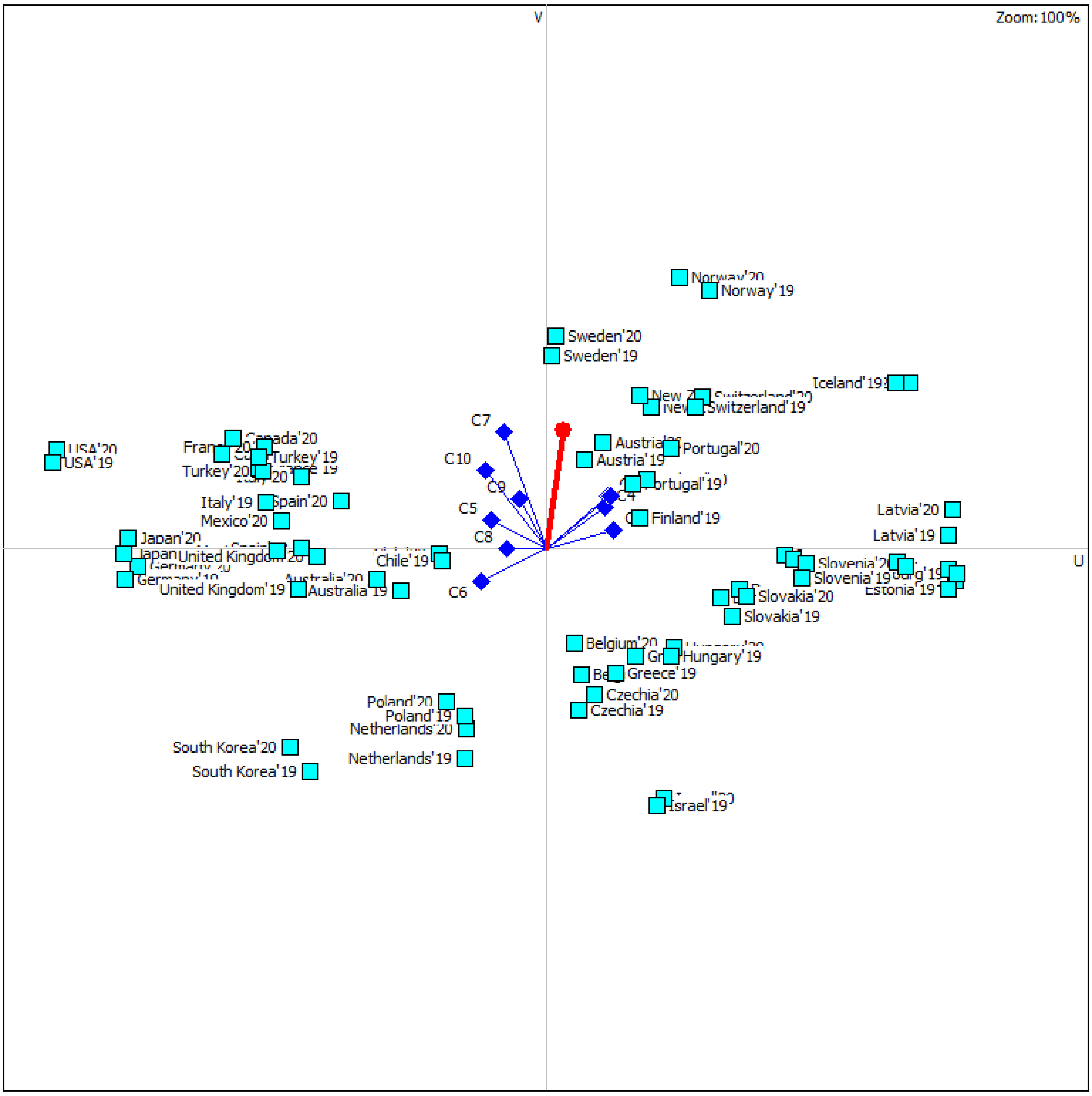
The PROMETHEE II assessment on the GAIA plane is shown in Figure 6. This graph was generated employing PROMETHEE IV. In fact, there are two possible outcomes:

1. When the Brain is completely located inside one side of the GAIA plane, the Decision Axis is constantly positioned in the same direction, implying that the PROMETHEE rankings should be stable. The preferred countries are easy to identify.

2. When the Brain overlaps the GAIA plane's center, it indicates that the Decision Axis is orientable in any direction. Thus, the PROMETHEE ranks might be very different depending on the weight values used within the limits set by the decision maker. As a result, the issue becomes far more difficult to evaluate. The location of nations on the criterion axis illustrates how well their activities perform on the various criteria.

Figure 6

GAIA Graphic



Consider the criteria C6 in Figure 6 (solar electricity generation). The orientation of the corresponding axis is critical: in this example, the C6 axis is orientated to the left. This means that the further to the left of the GAIA plane a nation is, the better it is at meeting criteria C6. According to the C6 criteria axis orientation, the 'best' values are on the left and the 'worst' values are on the right. Each country is projected orthogonally on the criteria direction. The forecasts depict the relative performance of the countries on the selected criteria. Distance from the criteria is significant. What important is the country's projected position on the criteria. In the Figure 6:

· USA '20 is clearly the best country (in terms of C6 solar electricity generation criterion), USA '19 value is closest to this value.

· Japan '20 and Japan '19 are the second best (in terms of solar electricity generation) and have very similar values,

· Finland'19 is worse than USA and Japan in terms of C6 criteria,

· Iceland'19 and Iceland'20 have the worst value for C6 solar electricity generation criterion

Naturally, this information is limited by the quality of the GAIA plane. The Decision Axis is a visual representation of the weighing of the criteria in the GAIA plane. As weights are allocated to the criteria the best countries in the PROMETHEE rankings are more or less influenced by the different criteria. The Decision Axis is similar to a weighted average of the criteria axes. It indicates the direction of the PROMETHEE II ranking and thus show which criteria are in agreement with the PROMETHEE II ranking and which are not. This can be beneficial for identifying factors that are under- or over-weighted.

In the Figure 2 one can see that with the current weights of the criteria, PROMETHEE will probably propose countries that are good on C1 (Gasoline consumption, thousand barrels per day), C2 (Fossil fuels electricity generation, billion kilowatt hours), C3 (Coal consumption, thousand short tons), C4 (Coal imports, thousand short tons), C7 (Hydroelectricity generation, billion kilowatt hours) and C10 (Renewable power generation, billion kilowatt hours). When the weights of the criteria are modified, the position of the Decision Axis changes.

When studying the GAIA plane, it is critical to consider the length of the Decision Axis. A short Decision Axis indicates that it is angled away from the GAIA plane and hence poorly represented. The Decision Axis's direction becomes much less useful in this case. Actually, the Decision Axis is the projection of the weight vector (Decision Stick) on the GAIA plane. In the Visual PROMETHEE, the U-V plane has a very high-quality level close to 90% (actually 83.4%). Thus, the third axis contributes just a marginal gain in quality. The 3D representation quality level is equal to 91%. When evaluating the U-W (quality level: 70%) or W-V (quality level: 21%), it should be remembered that the third axis accounts for 8% of the overall quality level. Therefore, the U is by far the most informative axis. Consequently, the significant distinctions between these 36 nations may be described using a single axis.

On the GAIA plane, alternatives (countries) are represented as points, while criteria are represented as vectors. For example, Sweden, Norway, Switzerland and Iceland among the countries tried to be ranked are in the direction of the best compromise solution because they are in the direction indicated by the decision stick. Netherlands, South Korea, Poland and Israel, which are in the opposite direction of these countries, are the countries in the worst position in terms of the criteria included in the analysis. On the GAIA plane, it can be said that the countries clustered together close to each other have similar profiles with each other in terms of energy criteria. Similarly, it can be said that the differences in the values of the energy criteria of the countries that are far from each other on the plane are large. Showing the single criterion net flows of the countries together reveals the profiles of the countries. In order to show that the two countries located close to each other on the GAIA plane are similar to each other, Sweden, Switzerland and Norway, which are at the top of the ranking and close to each other on the plane, and Turkey, which are located in opposite directions, are selected as an example and in Figure 7, profile graphics are presented in terms of criteria. It can be noticed that the countries that are close to each other have very similar profile graphs in terms of their advantageous and disadvantageous indicators.

Visual PROMETHEE software is used to generate some helpful graphical representations. Among these is the Rainbow diagram (see Figure 8 and Figure 9). This graphic is beneficial since it summarizes the advantages and disadvantages of each alternative (in this case, countries). The advantages are shown above the histograms, while the disadvantages are displayed below. As seen in Figure 8 and Figure 9, the top five ranked nations have a greater number of advantages than disadvantages, which contributes to their favorable position in the final ranking.

Figure 7

Action Profile of Countries

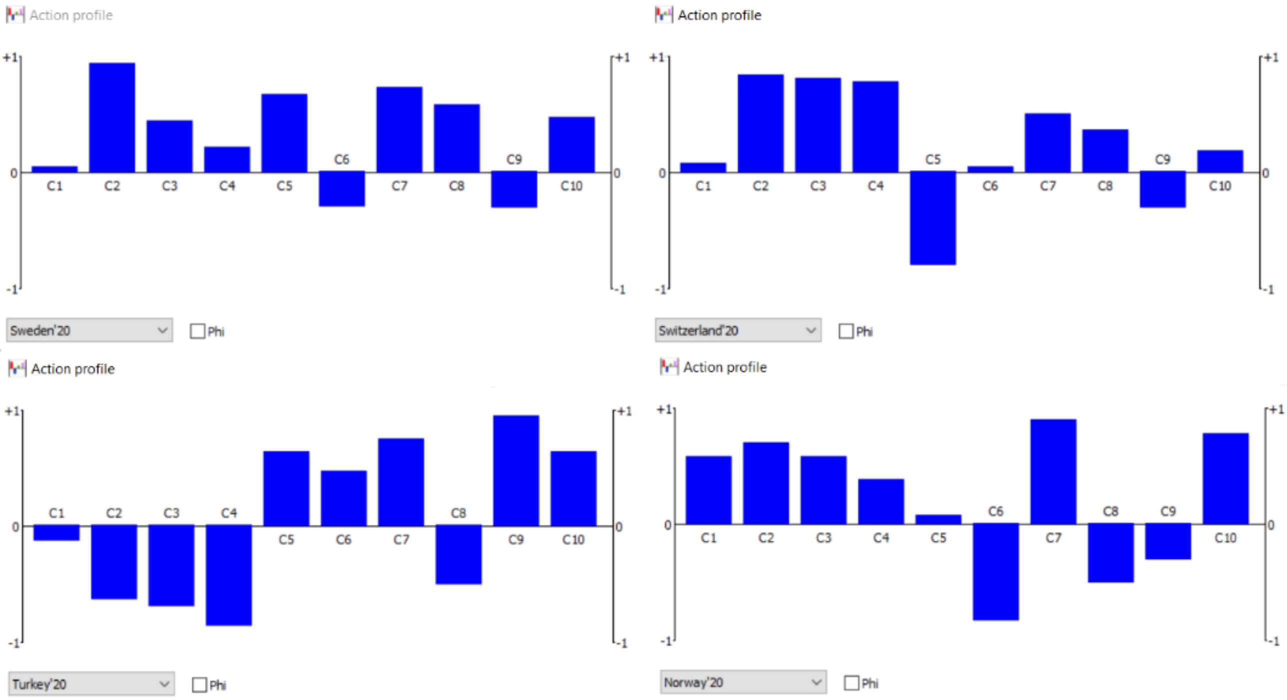


Figure 8

Rainbow Diagram for 2019

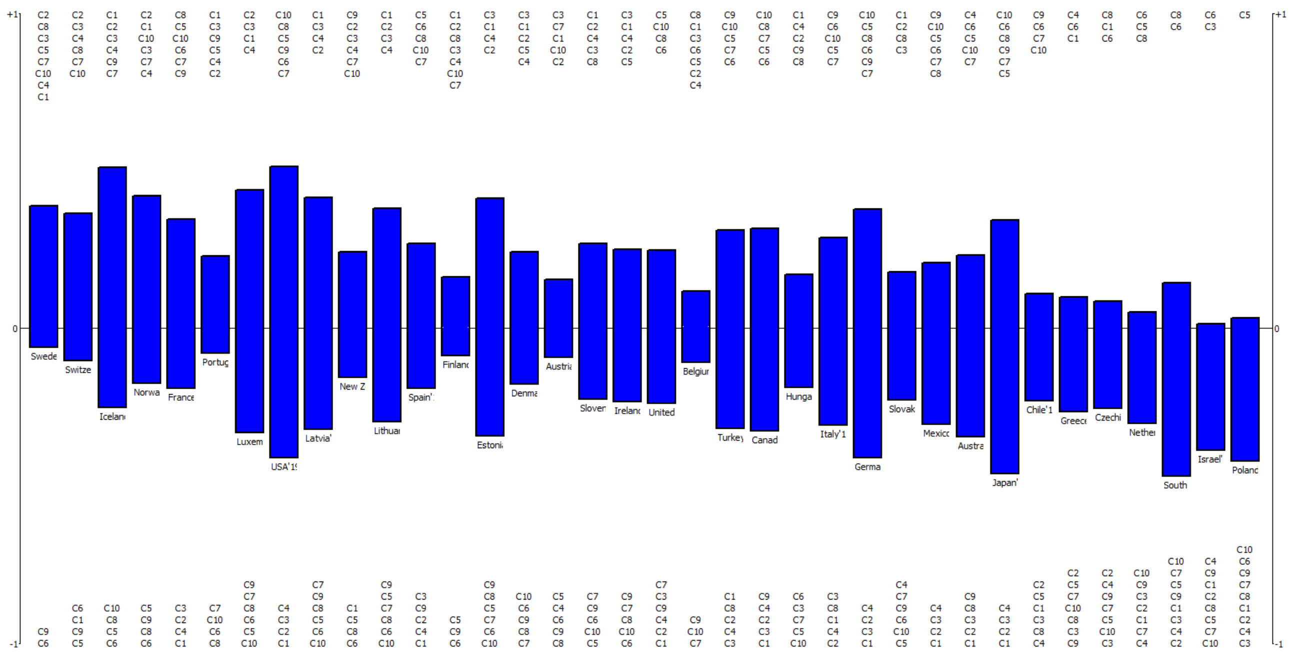
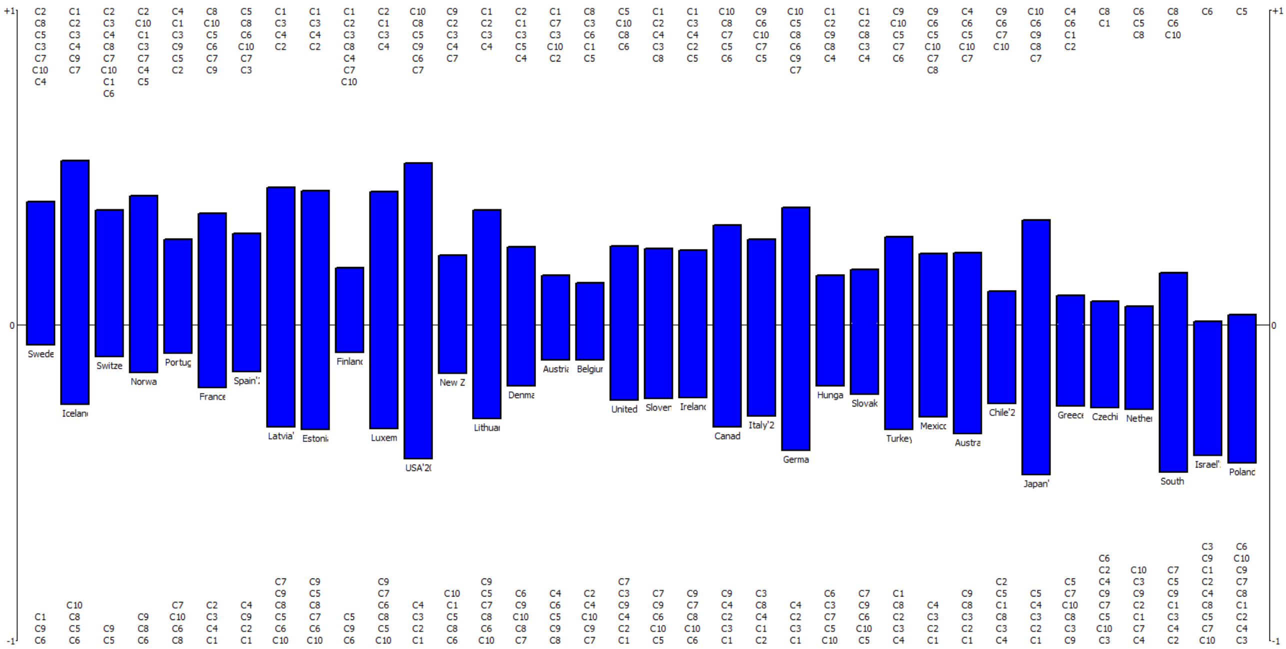


Figure 8

Rainbow Diagram for 2019 (Continued)



Discussion

The most important limitation of this study is the lack of a comprehensive database that would allow the evaluation of all countries or the majority of them together. In addition, the difficulties experienced in obtaining up-to-date data from countries and the lack of data from large economies such as China, India and Russia in databases such as the World Bank limit the scope of the study. In order to solve this problem, it is important to determine common indicators and to collect and publish data periodically over a common database. The novelty of the study is that it provides important data about the current literature on energy and that 36 countries with significant economic power from almost all continents are evaluated in terms of energy consumption and preferences with both pre-pandemic 2019 and 2020 pandemic data.

Since MCDM methods such as the Analytic Network Process (ANP) and Analytic Hierarchy Process (AHP) are based on subjective evaluations, very different results can be obtained in different analyses for the same indicators. When the criterion weights are determined by subjective evaluations, the results obtained by the same methods for the same indicators will be different. In this study, the MCDM methods were used, with the criteria being objectively weighted and not requiring any subjective evaluation, and only processing and evaluating the criteria values. In other words, the evaluations were carried out in a completely objective framework. Due to the computational differences of other MCDM methods, there may be some differences in the rankings obtained in future studies. When the results from the study are evaluated in general, the results are consistent with the rankings of other studies in the literature.

In this study, it is emphasized how the objective weights should be and which indicators come to the fore in the comparison of these countries by analyzing the energy indicators, taking into account the values of the countries being compared. The strengths and weaknesses and relative comparisons of these countries in their current situation are presented. The dimension with the largest weight, according to the study's Entropy analysis, is "C1 Gasoline consumption, thousand barrels per day". In addition, the study focuses on the renewable and fossil fuel consumption levels of countries and the change in consumption habits between periods. The study compares the leading countries from all continents using objective assessment methodologies such as entropy and PROMETHEE and also compares the results obtained from this study with the studies described in the literature review section. Rather than addressing a specific country or region, as is done in many studies, it is aimed to make an assessment on a global scale as much as possible.

The PROMETHEE method is slightly more advantageous than other methods in terms of visually evaluating both the similarities of countries and similar and different country groups in terms of indicator values. In addition, as it is emphasized in the literature review section about the method, the fact that it is a preferred method in energy and environmental management studies is the reason why it was preferred in this study.

The results of this study are similar to the results of the Rita et al. (2021) study, and it is seen that the renewable energy production and consumption tendencies of the countries increased during the pandemic period and increased their capacities in this direction. Of course, this shows that there is a meaningful progress in improving air quality and in the fight against global warming.

Phillis et al. (2021) proposed a framework for defining and measuring the sustainability of national energy systems. The framework had an application of the PROMETHEE method to evaluate the sustainability performance of 43 European countries.

When the results of Phillis et al. (2021) and the rankings of the same countries analyzed in both studies are evaluated together, Sweden, Switzerland, Norway, Iceland, France, Spain and Portugal are at the top of the rankings, while Turkey, Hungary, Greece and Czechia are among the countries with lower rankings and at the bottom of the list. Although there are two studies that deal with different aspects of energy, they produce similar results in terms of leading and underperforming countries. This shows the consistency of the study with the literature.

Conclusion

It is hoped that, in accordance with the Paris Climate Agreement's aims, the rise in air temperature would be limited to 1.5 degrees Celsius until 2050. To accomplish this, the European Union (EU) increased its emission reduction target to 55 percent in 2030. The EU aims to use an average of 32 percent renewable energy by 2030 and to be carbon-neutral by 2050. Additionally, the transition of companies to clean energy on their own initiative can make a significant contribution to reducing carbon emissions, which is encouraged by several regulations. Contribution of renewables in the energy mix of a country is now more important than ever. A higher share of renewable energy sources implies less pollution, fewer CO2 emissions, and a decreased contribution to climate change.

The Covid-19 crisis and the measures taken to slow its spread have had a profound impact on energy demand not seen in 70 years. This unique situation, along with government incentive packages, will significantly change the energy industry in the future years. Additionally, it will have a significant impact on the energy sector, energy security, and clean energy transitions in general.

When the literature was reviewed, it was determined that there is a need for new studies on the evaluation of energy use preferences and policies of countries and the energy situation of the countries before and during the pandemic. In order to fill this gap, an energy evaluation was aimed in a very broad framework in terms of content and scope. This study aimed to compare and evaluate 36 countries with data on all indicators by taking advantage of Entropy-based PROMETHEE methods. PROMETHHE methods were also preferred because they are the most preferred MCDM methods in environmental and energy issues, as stated in the literature review.

As a result of entropy calculations, while the criterion with the highest importance is the gasoline consumption criterion with a value of 14.12%, the criterion that follow this criteria in order are the fossil fuels electricity generation (12.25%); coal consumption (11.8%); coal imports (10.52%); renewable power generation (10.29%); nuclear power generation (9.7%); geothermal electricity generation (8.47%); wind electricity generation (8.47%); solar electiricity generation (8.15%); hydroelectricity generation (6.23%).

According to the results of the study, Sweden ranks first among other nations in terms of net Phi values for energy criterion using both 2019 and 2020 data. Sweden, Switzerland, Norway, Iceland, Portugal and France are at the top of the list, whereas Czechia, Netherlands, Greece, South Korea, Poland, Israel are at the bottom. According to the PROMETHEE II score values for 2020 and 2019, all of the countries in the top 10 of the list are EU countries. This situation shows how well the European Union and its member countries' renewable energy transition plans are being implemented. These nations are followed by the United States of America and New Zealand. The last of the list consists of Australia, Chile, Mexico, Japan, Israel, South Korea and some EU countries such as Greece and the Netherlands. As a result, the countries at the end of the PROMETHEE II ranking do not belong to a particular area, as at the beginning of the list.

Alternatives (countries) on the GAIA plane are shown as points and criteria are shown as vectors. For example, Sweden, Norway, Switzerland and Iceland, which are tried to be ranked, are in the direction of the best compromise solution because they are in the direction indicated by the decision stick. Netherlands, South Korea, Poland and Israel, which are in the opposite direction of these countries, are the countries in the worst position in terms of the criteria included in the analysis. On the GAIA plane, it can be said that the countries clustered close to each other have similar profiles with each other in terms of energy criteria.

Sweden, as the first ranked country, is a good performer in all the observed aspects except for the level of C6 (Solar electricity generation, billion kilowatt hours) and C9 (Geothermal electricity generation, billion kilowatt hours). At the very bottom of the rankings, there is Poland, with advantages only regarding the low level of C5 (Wind electricity generation, billion kilowatt hours) indicator.

The study presents an important novelty and contribution to the literature by taking into account the content of the indicators used, the scope of the countries it deals with, the data of the pandemic period and before. Another key aim and contribution of this study is to propose an integrated framework for defining and evaluating national energy sustainability based on Multiple Criteria Decision Making (MCDM) to overcome certain weaknesses of composite indicators related to weighting, summation and robustness. The preferred method is PROMETHEE, an MCDM approach that has an important perspective in measuring sustainability, given that a country's poor performance in a particular sustainability indicator may not be compensated for by good performance in other indicators.

The political and social implications and recommendations to be drawn from this study can be summarized as follows:

Renewables generated 38% of Europe's electricity in 2020 (up from 34.6 percent in 2019), surpassing fossil-fuel production, which decreased to 37%. This is a watershed moment in Europe's shift to a clean energy future. Germany and Spain (and, separately, the United Kingdom) also reached this goal for the first time. However, the shift from coal to renewable energy is still too inadequate to achieve a 55 percent decrease in greenhouse gas emissions by 2030 and climate balance by 2050.

While Covid-19 had an effect in every country, it had a negligible effect on the overall movement away from fossil fuels toward renewables. Renewable energy growth has been encouragingly strong in the face of the pandemic, and the decline in fossil-fired power might have been much greater had it not been for such a strong rebound in electricity demand and the worst year on record for nuclear output. Wind and solar energy are driving Europe's renewable energy growth. Wind generation increased by 9% in 2020, while solar generation increased by 15%. In 2020, they will produce one-fifth of Europe's electricity. Since 2015, wind and solar have catalyzer for all of Europe's renewable energy expansion, whereas bioenergy progress has declined and hydro capacity has remained stable.

Renewable energy development is still too weak – wind and solar power should almost treble to meet Europe's 2030 green agreement targets: from 38 TWh per year on average between 2010 and 2020 to 100 TWh per year on average between 2020 and 2030. It is positive that wind and solar combined rose by 51 terawatt-hours in

2020, far more than the average for the period 2010-2020, despite some damage of pandemic. In 2021, the IEA forecasts an unprecedented increase in wind and solar installations. Furthermore, EU member states' 2030 obligations must be significantly increased.

Coal production decreased 20% in 2020 and has been shortened in half since 2015. Coal generation declined in practically every nation, accelerating the coal industry's decline that began far before Covid-19. Half of the 2020 decline was due to lower power usage, which reduced by 4% as a result of the effect of Covid-19; the other half was due to increased wind and solar energy generation. When power demand recovers in 2022, wind and solar energy will need to expand at a quicker pace if current coal price declines are to be continued. This situation indicates that Europe's energy was 29 per cent cleaner in 2020 than it was in 2015. The CO2 emission of electricity has decreased from 317 grams of CO2 per kilowatt-hour in 2015 to 226 grams in 2020.

Despite the pandemic, gas generation declined just 4% in 2020. In 2020, the majority of the decline in fossil fuels was in coal, not gas, since a solid carbon price made gas generation the cheapest type of fossil power, even undercutting lignite for the first time in many months. Nuclear production decreased by 10% in 2020 – the greatest decline in history – and this also prevented gas (and, to a lesser degree, coal) production from decreasing more. Wind and solar development have pushed coal into decline, but it's just the start. Europe is counting on wind and solar energy to not just phase out coal by 2030, but also to phase out gas production, substitute closed nuclear energy installations, and satisfy increased electricity usage from electric vehicles, heating systems, etc.

Comparing the 2020 and 2019 data, the COVID-19 pandemic and supply shortages in the supply chain of fossil resources enabled important decisions to be taken on a national and international basis for a clean and sustainable environment. Countries increased their share of clean and renewable energy investments and started new projects. In order to ensure the sustainability of the energy they need and to reduce foreign dependency, more awareness has begun to emerge on renewable energy. The results of the study show that while the energy preferences of the countries in the 2020 pandemic period are in favor of renewable energy, the analysis scores are better compared to 2019. On the contrary, Turkey's 2019 score is slightly better than in 2020. This shows that Turkey should attach importance to the development of policies, projects and action plan similar to the trend of the world, rather than fossil fuels.

The countries that are dependent on foreign energy must replace this dependency with alternative energy sources suitable for their geography and resources in order to have a more sustainable economic system, stable inflation level and standard of living. As of January 2022 in Turkey, fuel prices have nearly doubled compared to 5 months ago. Turkey's energy imports were approximately 55 billion dollars in 2021. While the average over the previous decade has been 45 billion dollars, this rise is due to increased natural gas usage and higher unit pricing Therefore, it is expected that the bill and price paid by the citizen will increase gradually. It is predicted that this amount will increase even more in 2022. Turkey imports 250 billion dollars annually. Thus, energy imports totaling 55 billion dollars account for 22% of Turkey's overall imports. Due to the current account deficit and inflationary implications of foreign dependence on energy supplies, it poses a significant danger to financial sustainability and social wellbeing of countries. In this instance, Turkey has ratified the Kyoto Protocol as of 28 May 2009, so the use of nuclear energy is also very important in terms of meeting the obligations for the prevention of climate change. The first nuclear power plant to be implemented in Turkey will be Akkuyu Nuclear Power Plant with a capacity of 4800 MW to be established in Mersin's Gülnar district. After that, it is aimed to establish the Sinop Nuclear Power Plant with a capacity of 4400 MW to be established in Sinop.

As highlighted in the introduction, oil and its products saw their lowest values in history during the pandemic period. The increase in the production and consumption of renewable energy shows that countries that generate income from oil should create alternative income sources and invest in different sectors in terms of a sustainable economy.

The results of this and similar studies show that this period is an opportunity to direct and support the economy towards renewable energy sources, circular economy, and environmentally friendly transportation systems rather than oil. These developments will allow positive developments to emerge in emissions, public health, employment and many other environmental and other economic issues.

In future studies, the results obtained by different methods can be compared with this study. In addition, the study can be extended by using the data of countries such as China, India and Russia, which do not currently have data for some of the indicators used in this study.

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Appendix A

Entropy Decision Matrix

	Gasoline consumption, thousand barrels per day	Fossil fuels electricity generation, billion kilowatthours	Coal consumption, thousand short tons	Coal imports, thousand short tons	Wind electricity generation, billion kilowatthours	Solar electricity generation, billion kilowatthours	Hydroelectricity generation, billion kilowatthours	Nuclear power generation, billion kilowatthours	Geothermal electricity generation, billion kilowatthours	Renewable power generation, billion kilowatthours
Countries	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Australia '20	266.45	183.51	106908.64	183.34	20.4	21.03	16.2	0.1	0.01	57.3
Australia '19	306.61	198.66	112009.02	135.33	17.71	14.85	15.54	0.1	0.01	54.4
Austria '20	31.56	12.53	3218.17	3285.21	6.79	2.04	40.95	0.1	0.01	54.49
Austria '19	38.2	15.01	3520.34	4103.24	7.48	1.7	40.44	0.1	0.01	54.32
Belgium '20	37.41	28.35	3312.22	3599.28	12.87	4.97	0.33	32.6	0.01	23.98
Belgium '19	44.7	26.99	4039.19	4087.15	9.73	4.25	0.11	41.42	0.01	20.04
Canada '20	753.92	103.85	25173.45	6935.84	36.1	4.28	383	92.64	0.01	430.68
Canada '19	875.19	112.9	32227.13	8952.4	32.66	4.08	377.98	94.85	0.01	423.82
Chile '20	68.67	41.44	11333.19	11688.59	5.52	7.62	20.58	0.1	0.25	38.18
Chile '19	80.04	42.86	13063.58	11490.77	4.9	6.14	20.67	0.1	0.2	36.44
Czechia '20	33.9	35.51	38820.23	3950.28	0.7	2.24	2.15	28.37	0.01	9.9
Czechia '19	37.41	40.71	45963.68	4208.91	0.7	2.26	1.99	28.58	0.01	10.14
Denmark '20	28.7	4.21	1363.66	1224.66	16.35	1.18	0.02	0.1	0.01	23.24
Denmark '19	30.72	5.27	1740.49	2631.6	16.15	0.96	0.02	0.1	0.01	24.01
Estonia '20	5.02	3.29	3.82	3.82	0.84	0.12	0.04	0.1	0.01	1.77
Estonia '19	6.35	4.61	19.61	19.61	0.69	0.07	0.02	0.1	0.01	2.19
Finland '20	30.75	8.98	2911.2	2603.99	7.94	0.26	15.65	22.36	0.01	34.59
Finland '19	32.8	11.46	3923.45	3392.37	6.03	0.15	12.31	22.92	0.01	32.3
France '20	174.19	44.55	8749.7	8194.92	40.7	13.58	60.75	335.41	0.13	129.27
France '19	203.36	48.21	10897.19	11588.67	34.72	12.23	56.98	382.4	0.13	118.59
Germany '20	452.68	221.66	151834.66	32963.5	130.97	50.6	19.27	60.92	0.22	253.14
Germany '19	495.52	257.9	188824.59	45577.35	125.89	46.39	19.86	70.98	0.2	246.54
Greece '20	43.96	22.94	15242.35	335.49	9.32	4.36	3.38	0.1	0.0001	17.7
Greece '19	52.82	27.91	29691.11	359.92	7.27	4.43	3.98	0.1	0.0001	17.08
Hungary '20	31.31	11.91	8243.07	1529.02	0.66	2.45	0.24	15.17	0.02	5.6
Hungary '19	34.96	11.81	9143.66	1790.97	0.73	1.5	0.22	15.41	0.02	4.94
Iceland '20	2.37	0.0001	141.85	135.64	0.01	0.001	13.03	0.1	5.96	18.91
Iceland '19	2.9	0.0001	156.93	164.9	0.01	0.001	13.32	0.1	6.02	19.26
Ireland '20	13.25	19.17	378.3	440.71	11.55	0.06	0.95	0.1	0.01	12.22
Ireland '19	17.78	17.99	643.74	393.85	10.02	0.02	0.88	0.1	0.01	11.43
Israel '20	62.21	64.2	5609.99	6133.85	0.23	4.07	0.01	0.1	0.01	0.1
Israel '19	71.7	64.67	6499.65	6499.75	0.18	3.29	0.01	0.1	0.01	0.1
Italy '20	136.8	152.36	8518.4	8606.13	18.7	24.94	45.44	0.1	6.03	117.28
Italy '19	176.53	165.7	11425.19	11933.27	20.2	23.71	45.32	0.1	6.08	117.05
Japan '20	756.4	655.13	203062.19	191439.48	8.65	78.64	85.5	40.81	2.85	257.21
Japan '19	853.65	698.91	206516.8	205232.69	7.67	68.95	79.82	65.68	2.83	225.54
Latvia '20	4.3	1.82	43.3	43.73	0.18	0.01	2.57	0.1	0.01	3.55
Latvia '19	4.28	2.89	74.37	87.47	0.15	0.001	2.09	0.1	0.01	3.17
Lithuania '20	5.86	1.66	223.7	276.01	1.55	0.13	0.39	0.1	0.01	2.62
Lithuania '19	5.78	0.51	289.58	408.72	1.5	0.09	0.34	0.1	0.01	2.53
Luxembourg '20	6.37	0.17	71.93	81	0.34	0.18	0.12	0.1	0.01	1.01
Luxembourg '19	8.33	0.19	70.67	78.59	0.28	0.13	0.11	0.1	0.01	0.8
Mexico '20	546.78	231.26	9281.45	4581.78	19.7	13.53	27.11	11.09	4.52	65.73
Mexico '19	752.53	250.08	18533.14	8867.71	16.88	7.06	23.85	10.88	5.35	55.36
Netherlands '20	85.49	80.27	7196.69	23469.18	15.34	7.99	0.05	3.86	0.01	30.25
Netherlands '19	100.27	88.95	11232.54	41513.99	11.51	5.16	0.07	3.7	0.01	22.7
New Zealand '20	50.81	8.51	2847.28	1189.76	2.3	0.16	23.73	0.1	8.14	34.37
New Zealand '19	56.59	7.62	2940.8	1184.59	2.25	0.13	25.33	0.1	7.44	35.77
Norway '20	16.75	1.83	904.33	902.48	9.91	0.03	139.18	0.1	0.01	149.67
Norway '19	17.72	2.5	888.3	874.95	5.54	0.01	123.66	0.1	0.01	129.65
Poland '20	101.73	116.72	119540.52	14416.79	15.8	1.99	2.15	0.1	0.01	27.66
Poland '19	109.16	125.47	131484.3	18764.99	15.11	0.71	1.94	0.1	0.01	25.14
Portugal '20	20.98	20.59	1046.5	253.16	12.26	1.68	11.87	0.1	0.22	29.66
Portugal '19	24.71	23.37	2321.3	3135.35	13.67	1.34	8.65	0.1	0.22	27.3
Slovakia '20	12.09	5.49	4562.46	3241.99	0.01	0.66	4.47	14.05	0.01	6.69
Slovakia '19	13.06	5.56	5708.86	4199.84	0.01	0.59	4.27	14.28	0.01	6.16
Slovenia '20	7.41	4.46	3835.69	345.1	0.01	0.37	5.02	6.04	0.01	5.59
Slovenia '19	9.28	4.53	3830.23	481.59	0.01	0.3	4.43	5.53	0.01	5
South Korea '20	218.37	357.04	138064.78	136127.44	3.15	18.25	3.2	152.3	0.01	45.26
South Korea '19	226.71	390.78	146354.91	155861.94	2.68	13.02	2.75	138.81	0.01	31.21
Spain '20	97.98	82.55	3960	4375.26	56.27	20.54	30.59	55.76	0.01	112.19
Spain '19	124.44	106.33	8460	9467.65	55.65	15.1	24.23	55.86	0.01	100.26
Sweden '20	48.46	0.17	2347.92	2231.68	27.53	1.04	71.04	47.26	0.01	111.4
Sweden '19	51.08	1.63	2631.21	2574.86	19.85	0.68	64.47	64.43	0.01	98.56
Switzerland '20	47.83	0.52	151.29	138.68	0.15	2.52	37.72	22.99	0.01	43.3
Switzerland '19	54	0.61	158.91	139.37	0.15	2.18	37.66	25.37	0.01	43.22
Turkey '20	54.45	165.04	113734.81	44363.5	24.7	11.27	77.2	0.1	9.93	124.65
Turkey '19	54.03	158.7	137176	41615.14	21.73	9.25	88	0.1	8.95	130.21
United Kingdom '20	221.82	113.33	7795.56	4990.53	75.61	12.8	5.92	45.67	0.01	137.41
United Kingdom '19	285.02	134.13	8797.02	6866.27	64.34	12.68	5.9	51.03	0.01	124.61
USA '20	8033.7	2419.23	535400	5350	337.51	132.63	291.11	789.92	16.93	847
USA '19	9309.34	2581.7	588414.63	6696.53	295.88	106.89	287.87	809.41	15.47	776.96

Appendix B

PROMETHEE Decision Matrix

Countries	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Australia '20	0.971626	0.928919	0.818316	0.999125	0.060415	0.158555	0.042273	0	0.000585	0.06754
Australia '19	0.967311	0.923051	0.809648	0.999359	0.052444	0.111959	0.040549	0	0.000585	0.064116
Austria '20	0.996864	0.995147	0.994537	0.984011	0.020089	0.015374	0.106896	0	0.000585	0.064222
Austria '19	0.99615	0.994186	0.994024	0.980025	0.022133	0.01281	0.105564	0	0.000585	0.064022
Belgium '20	0.996235	0.989019	0.994377	0.982481	0.038104	0.037465	0.000836	0.040158	0.000585	0.028197
Belgium '19	0.995452	0.989546	0.993142	0.980104	0.0288	0.032037	0.000261	0.051056	0.000585	0.023545
Canada '20	0.919249	0.959775	0.957224	0.966223	0.106933	0.032263	1	0.114344	0.000585	0.508419
Canada '19	0.906219	0.956269	0.945237	0.956397	0.096741	0.030755	0.986893	0.117075	0.000585	0.500319
Chile '20	0.992876	0.983949	0.980746	0.943065	0.016326	0.057446	0.053709	0	0.014761	0.044964
Chile '19	0.991655	0.983399	0.977805	0.944029	0.014489	0.046287	0.053944	0	0.011808	0.042909
Czechia '20	0.996612	0.986246	0.934032	0.98077	0.002044	0.016882	0.005588	0.034931	0.000585	0.011572
Czechia '19	0.996235	0.984231	0.921892	0.97951	0.002044	0.017032	0.00517	0.03519	0.000585	0.011855
Denmark '20	0.997171	0.998369	0.997689	0.994051	0.048415	0.008889	0.000104	0	0.000585	0.027323
Denmark '19	0.996954	0.997959	0.997049	0.987196	0.047822	0.007231	0.000104	0	0.000585	0.028232
Estonia '20	0.999715	0.998726	1	1	0.002459	0.000897	0.000104	0	0.000585	0.001972
Estonia '19	0.999572	0.998214	0.999973	0.999923	0.002015	0.00052	0.000104	0	0.000585	0.002468
Finland '20	0.996951	0.996522	0.995059	0.98733	0.023496	0.001953	0.040837	0.027505	0.000585	0.040725
Finland '19	0.99673	0.995561	0.993339	0.983489	0.017837	0.001123	0.032116	0.028197	0.000585	0.038021
France '20	0.981539	0.982744	0.985136	0.960088	0.120563	0.102383	0.158594	0.414316	0.007673	0.152521
France '19	0.978404	0.981326	0.981487	0.943552	0.102844	0.092205	0.148751	0.472378	0.007673	0.13991
Germany '20	0.951616	0.914142	0.741965	0.8394	0.38803	0.381508	0.050289	0.07515	0.012989	0.298784
Germany '19	0.947013	0.900105	0.6791	0.777938	0.372978	0.349765	0.051829	0.087581	0.011808	0.290991
Greece '20	0.995531	0.991114	0.974102	0.998384	0.027585	0.032866	0.008799	0	0	0.020782
Greece '19	0.994579	0.989189	0.949547	0.998265	0.021511	0.033394	0.010366	0	0	0.02005
Hungary '20	0.996891	0.995387	0.985997	0.992568	0.001926	0.018465	0.000601	0.018621	0.001175	0.006494
Hungary '19	0.996498	0.995426	0.984467	0.991292	0.002133	0.011302	0.000548	0.018917	0.001175	0.005715
Iceland '20	1	1	0.999765	0.999358	0	0	0.033996	0	0.352034	0.02221
Iceland '19	0.999943	1	0.99974	0.999215	0	0	0.034753	0	0.355578	0.022624
Ireland '20	0.998831	0.992575	0.999364	0.997871	0.034193	0.000445	0.002454	0	0.000585	0.014311
Ireland '19	0.998344	0.993032	0.998912	0.9981	0.029659	0.000143	0.002272	0	0.000585	0.013378
Israel '20	0.99357	0.975133	0.990472	0.970131	0.000652	0.03068	0	0	0.000585	0
Israel '19	0.992551	0.974951	0.98896	0.968348	0.000504	0.024798	0	0	0.000585	0
Italy '20	0.985556	0.940985	0.98553	0.958084	0.055378	0.188036	0.118619	0	0.356169	0.138363
Italy '19	0.981287	0.935818	0.980589	0.941872	0.059822	0.178762	0.118306	0	0.359122	0.138092
Japan '20	0.918982	0.746241	0.654904	0.067209	0.0256	0.592925	0.223217	0.050302	0.168335	0.30359
Japan '19	0.908533	0.729283	0.649033	0	0.022696	0.519864	0.208387	0.081032	0.167154	0.266194
Latvia '20	0.999793	0.999295	0.999933	0.999806	0.000504	0.000143	0.006684	0	0.000585	0.004074
Latvia '19	0.999795	0.998881	0.99988	0.999592	0.000415	0.000143	0.005431	0	0.000585	0.003625
Lithuania '20	0.999625	0.999357	0.999626	0.998674	0.004563	0.000973	0.000992	0	0.000585	0.002976
Lithuania '19	0.999634	0.999802	0.999514	0.998027	0.004415	0.000671	0.000862	0	0.000585	0.002869
Luxembourg '20	0.99957	0.999934	0.999884	0.999624	0.000978	0.00135	0.000287	0	0.000585	0.001075
Luxembourg '19	0.99936	0.999926	0.999886	0.999636	0.0008	0.000973	0.000261	0	0.000585	0.000827
Mexico '20	0.941505	0.910423	0.984233	0.977693	0.058341	0.102006	0.070759	0.013579	0.266977	0.077494
Mexico '19	0.919398	0.903134	0.96851	0.95681	0.049985	0.053224	0.062247	0.01332	0.316003	0.06525
Netherlands '20	0.991069	0.968908	0.987776	0.885662	0.045422	0.060236	0.000104	0.004646	0.000585	0.0356
Netherlands '19	0.989481	0.965546	0.980917	0.797737	0.034074	0.038898	0.000157	0.004448	0.000585	0.026686
New Zealand '20	0.994795	0.996704	0.995168	0.994221	0.006785	0.001199	0.061934	0	0.4808	0.040465
New Zealand '19	0.994174	0.997048	0.995009	0.994247	0.006637	0.000973	0.066111	0	0.439453	0.042118
Norway '20	0.998455	0.999291	0.99847	0.995621	0.029333	0.000219	0.363378	0	0.000585	0.176609
Norway '19	0.998351	0.999032	0.998497	0.995755	0.016385	0.000106	0.322854	0	0.000585	0.15297
Poland '20	0.989324	0.95479	0.796848	0.929771	0.046785	0.014997	0.005588	0	0.000585	0.032542
Poland '19	0.988526	0.9514	0.77655	0.908584	0.044741	0.005346	0.005039	0	0.000585	0.029567
Portugal '20	0.998	0.992025	0.998228	0.998785	0.036296	0.012659	0.030967	0	0.012989	0.034904
Portugal '19	0.9976	0.990948	0.996061	0.984741	0.040474	0.010096	0.022559	0	0.012989	0.032117
Slovakia '20	0.998956	0.997874	0.992253	0.984222	0	0.004969	0.011645	0.017237	0.000585	0.007781
Slovakia '19	0.998851	0.997846	0.990304	0.979554	0	0.004441	0.011123	0.017521	0.000585	0.007156
Slovenia '20	0.999458	0.998272	0.993488	0.998337	0	0.002782	0.013081	0.00734	0.000585	0.006482
Slovenia '19	0.999258	0.998245	0.993497	0.997672	0	0.002254	0.011541	0.006709	0.000585	0.005786
South Korea '20	0.976792	0.861704	0.765366	0.336723	0.009304	0.137594	0.008329	0.188061	0.000585	0.053324
South Korea '19	0.975895	0.848635	0.751277	0.240564	0.007911	0.098161	0.007154	0.171393	0.000585	0.036734
Spain '20	0.989727	0.968025	0.993277	0.9787	0.166696	0.154861	0.079845	0.068775	0.000585	0.132353
Spain '19	0.986884	0.958814	0.985629	0.953886	0.164859	0.113844	0.063239	0.068898	0.000585	0.118267
Sweden '20	0.995048	0.999934	0.996016	0.989145	0.081541	0.007834	0.185462	0.058272	0.000585	0.13142
Sweden '19	0.994766	0.999369	0.995535	0.987472	0.058785	0.00512	0.168307	0.079487	0.000585	0.116259
Switzerland '20	0.995115	0.999799	0.999749	0.999343	0.000415	0.018993	0.098462	0.028283	0.000585	0.05101
Switzerland '19	0.994453	0.999764	0.999736	0.99934	0.000415	0.016429	0.098305	0.031224	0.000585	0.050915
Turkey '20	0.994404	0.936073	0.806715	0.783853	0.073156	0.084966	0.201546	0	0.58653	0.147066
Turkey '19	0.994449	0.938529	0.766877	0.797244	0.064356	0.069736	0.229745	0	0.528645	0.153631
United Kingdom '20	0.976421	0.956103	0.986758	0.975702	0.224	0.096502	0.015431	0.056307	0.000585	0.162132
United Kingdom '19	0.96963	0.948046	0.985056	0.966562	0.190607	0.095597	0.015379	0.06293	0.000585	0.147019
USA '20	0.137063	0.062931	0.090098	0.97395	1	1	0.760072	0.975918	1	1
USA '19	0	0	0	0.967389	0.876652	0.805925	0.751612	1	0.913762	0.917298