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EWI Future Energy Score: Assessing potential hydrogen exporters

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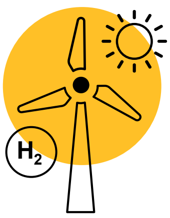

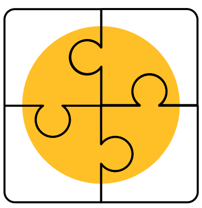
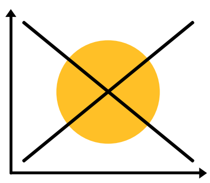
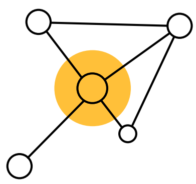

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Executive summary

Green or low-carbon hydrogen and hydrogen derivatives are essential in phasing out fossil fuels and reaching climate targets. Concerning the hydrogen market ramp-up in Germany and other countries worldwide, hydrogen is expected to become an important internationally traded energy good.

Especially in Germany, the demand for green hydrogen and hydrogen-based products is expected to increase significantly to reach climate neutrality. EWI calculations show that in 2045, only 10 % of the German hydrogen demand may be supplied by domestic production. Besides imports from countries in the European Union (EU) (238 TWh), the majority of German hydrogen demand, 55 %, is covered by imports from Non-EU countries (383 TWh) (EWI, 2021).

Many choices - A large number of countries can produce hydrogen

In contrast to fossil fuels, hydrogen, primarily when produced with renewable energies, can be produced in almost every country in the world. This enables countries that are expected to import large amounts of hydrogen or derivatives in the future to diversify their imports. 2050 about one-third of green hydrogen could be traded across borders (IRENA, 2022).

This study introduces the EWI Future Energy Score (EFES) based on four sub-indicators to compare potential hydrogen-exporting countries. Factors that pose a risk to stable and reliable future energy markets and may challenge or threaten the export of commodities like hydrogen and its derivatives are considered. The four assessed sub-indicators, which all interplay with each other, namely political, economic, social, and energy, are defined as follows:

- **Political sub-indicator:** The political risks of a country include internal and external conflict, terrorism, institutional instability, dysfunctional law and order, and the control of corruption.
- **Economic sub-indicator:** Economic factors include a country's economic stability, economic growth and wealth, the inflation rate, financial stability, and economic freedom.
- **Social sub-indicator:** Various societal factors in a country may foster social dissatisfaction. Social dynamics and pressures in a country can challenge political and economic stability. Social inequality, tensions, and resource conflicts can lead to instability.
- **Energy sub-indicator:** Various energy-related factors determine the risk potential of future energy exports as part of a country's energy sector. The energy intensity, the share of renewable energy sources in the energy system, a dependency on energy imports, experience in handling hydrogen or natural gas, investments in the energy sector, specifically in energy infrastructure, and R&D efforts influence the risks.

Creating a Country Score – The Principal Component Analysis (PCA)

The study uses a Principal Component Analysis (PCA) to create the EFES based on four sub-indicators. Each sub-indicator displays results for each country's performance, resulting in a different country ranking, as a country may perform better or worse in different sub-indicators. Each score ranks between 0 and 100. The higher a country's score, the better the country is performing. All four sub-indicators are equally weighted in the EFES, contributing 25 % to the final EFES. The EFES allows a new, multifaceted perspective as countries perform differently in the various sub-indicators.

The analysis has been conducted for 2017 to 2021 based on a dataset with various variables capturing the situation in a country. The analysis extracted 128 variables, including 34 economic, 19 political, 31 social, and 44 energy-related. Due to missing data, scores for every year may be unavailable for some countries.

The best-performing countries and countries with hydrogen partnerships with Germany

This study uses the EFES to analyze future hydrogen production in over 80 countries. The main result is a list of all considered countries with their EFES. A high value is interpreted as an indicator of sustainable hydrogen production and reliable export conditions.

For 2021, the EFES of the assessed countries range from 40 to 67, averaging 54. Norway, Germany, Canada, Australia, Switzerland, New Zealand, and the United Kingdom stand out as the best performers, all scoring between 64 and 67.

As Germany will rely on green hydrogen imports in the future, the German government already engages in energy and hydrogen partnerships with foreign countries, among others, to secure future hydrogen supplies. These countries should be well chosen considering their performance. By discussing these countries' scores, the analysis sheds light on Germany's hydrogen partnerships with Australia, Canada, Chile, Egypt, Morocco, Namibia, and Saudi Arabia. In 2021, Australia and Canada reached the highest scores among the official hydrogen partners, with 66 and 65, respectively, while closely followed by Chile, with an EFES of 61. Morocco (46), Saudi Arabia (46), and Egypt (45) all rank closely behind Namibia (50).

Outlook - How to use the EWI Future Energy Score

The EFES helps to compare countries with each other. Thereby, the score can support decision-makers in identifying suitable future hydrogen trading partners. The EFES can be applied as a first step in assessing the potential security of investments and the security of future hydrogen supply chains.

Besides potential hydrogen exporters' political, economic, social, and energy performance, production and transport costs and transport risks are other vital factors determining a solid import portfolio. Several studies and calculation tools on hydrogen supply costs are already available (e.g., PtX Cost Tool (EWI, 2022)). A combined assessment of the shown EFES and the supply costs can result in an even more holistic evaluation of suitable hydrogen partners.

1 Motivation

Besides direct electrification, green or low-carbon hydrogen and hydrogen derivatives play an important in future energy systems. Hydrogen and its derivatives are necessary to phase out fossil fuels and reach climate targets. Currently, hydrogen is primarily used as a feedstock in the industry. In 2021, approximately 48 TWh of grey hydrogen was consumed in Germany (EWI, 2023a). The demand for green hydrogen and hydrogen-based products is expected to increase significantly to reach climate neutrality.

A meta-analysis of German gas and hydrogen demands shows that the average hydrogen demand could reach 300 TWh per year in scenarios with climate neutrality. This potential hydrogen demand represents a six-fold increase compared to the German hydrogen demand in 2021 (Kopp et al., 2022). EWI calculations show that in 2045, only 10 % of the German hydrogen demand may be covered by domestic production. Besides imports from European Union countries (238 TWh), the majority of German hydrogen demand, 55 %, could be covered by imports from Non-EU countries (383 TWh) (EWI, 2021).

Germany's "National Hydrogen Strategy Update" outlines the goal to ensure sufficient availability of hydrogen and its derivatives. With the strategy, the German government declares a target of 10 GW installed electrolysis capacity for 2023 (Federal Ministry for Economic Affairs and Climate Action, 2023). Since demand is expected to be higher than can be produced with 10 GW of electrolyzers, imports will play an important role in meeting the domestic demand (Federal Ministry for Economic Affairs and Climate Action, 2023). This confirms the results of scenario-based studies such as (EWI, 2021).

Hydrogen and hydrogen derivatives are expected to develop into internationally traded commodities. In 2050, about one-third of green hydrogen could be traded across borders (IRENA, 2022). The development of a global hydrogen and derivatives market and the increasing investments in hydrogen technologies offer many opportunities for businesses and societies but also pose risks. International trade is influenced by various factors, including the economy, technological progress, industrial structure, economic and financial risks, political stability, population, natural disasters, and the environment (Li et al., 2022). Many of these factors are interconnected with the circumstances and progress within countries throughout the value chain, as well as global affairs. These factors pose risks to businesses, investors, trade, and the security of supply, collectively known as country risks (Li et al., 2022). With new hydrogen supply chains and significant import shares, risks of new dependencies and vulnerabilities may arise and challenge future supply security (IRENA, 2019, 2022).

In a previous study, "H_2 Geopolitics – Geopolitical Risks in Global Hydrogen Trade", EWI identified risks in potential hydrogen exporting countries for the German hydrogen supply security. The risks comprise political, economic, and social factors, as well as bilateral relations. Additionally, a risk assessment on four selected countries was conducted (EWI, 2023b). This study builds on the findings of the previous study and now creates an EWI Future Energy Score (EFES) using a Principal

Component Analysis (PCA). The EFES allows us to compare potential energy-exporting countries with respect to identified sub-indicators. The results are interpreted with respect to hydrogen.

In the following first, an extensive literature review focusing on the geopolitics of renewable energies and country risks sets the foundation for the analysis (Chapter 2). In Chapter 3, the identified sub-indicators, the dataset, and the methodological approach for the EFES are introduced. Finally, the EFES and sub-indicators are presented and discussed (Chapter 4).

2 On the concept of energy security and country risks

Over the last decade, the assessment of energy security and country risks has played an important role in the scientific discourse. This chapter delves into the literature on geopolitical risks in energy markets and country-specific risks. The literature review identifies appropriate comparable research approaches and applicable methodologies. This analysis complements existing literature with a focus on future global hydrogen trade.

Geopolitical risks in energy markets

Empirical studies have predominantly focused on the correlation of political and economic factors, fossil fuels, fossil stock prices, and CO_2 emissions. The research has shown that geopolitical risk has a negative impact on investments related to trade flows, tourism, and oil prices but has a positive effect on government investments (Aloui & Hamida, 2021; Antonakakis et al., 2017; Bilgin et al., 2020; Gozgor et al., 2022; Gupta et al., 2019).

There are mixed empirical findings regarding the effect of geopolitical risk on RES deployment (Casertano, Flouros et al., 2022; Nguyen et al., 2022; Su et al., 2021). Pan (2019) finds that RES is highly dependent on R&D, and geopolitical risk may negatively influence R&D investments. Whereas Cai & Wu (2021) and Su et al. (2021) imply that RES reduces geopolitical risks, on the other hand, higher geopolitical risks encourage and spread the use of renewable energy. Yang et al. (2021) also find positive spillover effects of geopolitical risk to the renewable energy stock in their analysis. Flouros et al. (2022) suggest that as renewable energy sources are not geographically concentrated like traditional energy sources, they are more prone to become subject to various geopolitical risks. Therefore, in order for a nation to ensure that any change in national energy policy is sustainable and effective, diversification of the energy mix should be seen as the proper strategy.

Risks to energy security: Country risks

Quantifying country-specific risks and assessing energy security is complex. Indicators and indices are valuable tools for identifying potential economic, social, environmental, security, and political risks. Nevertheless, they are not sufficient on their own to carry out a risk assessment. These indices are primarily intended to inform policymakers about the current state of the system by measuring inputs that can be taken as proxies for the potential risk and the level of impact on energy security (Lazarou & Branislav, 2022).

Brown et al. (2015) criticize that, in many cases, the analysis of country risks remains reliant upon a small set of variables for measuring the dimensions. Several approaches have been developed to quantify country-specific risks or the energy security of a specific country by employing numerical risk parameters (Bompard et al., 2017). Indicators are often chosen to be applicable to any technology or type of energy source underpinning the energy system under consideration. Nevertheless, identifying indicators purely based on preliminarily defined dimensions reduces the number of available indicators (Breitschopf & Schlotz, 2014; Cherp & Jewell, 2011; Sovacool & Mukherjee, 2011; Vivoda, 2010).

The European 7th Framework Programme project REACCESS (Risk of Energy Availability: Common Corridors for Europe Supply Security) used regression and factor analysis to generate and combine risk vectors to assess geopolitical risk quantitatively. These risk vectors consisted of socio-political, energetic, political-institutional, and economic dimensions and were then combined into an index for use in model-based scenario analysis (Marín-Quemada, Velasco, García-Verdugo et al., 2009; Marín-Quemada, Velasco, & Muñoz, 2009a, 2009b). Using the same method of factor analysis, Muñoz et al. (2015) defined the Geopolitical Energy Supply Risk Index or GESRI. By combining the social and political dimensions into a single risk vector and introducing a new vector reflecting the bilateral relations between exporting and transit countries with the EU-27, the authors extend the methodology used by Marín-Quemada, Velasco, García-Verdugo et al. (2009) and Marín-Quemada, Velasco & Muñoz (2009a, 2009b).

In addition to the risk assessment methodology employed in the REACCESS project or the GESRI, several other energy security indices have been developed, each with a different scope and degree of emphasis. The most common are the Supply-Demand Index, which considers the entire value chain and is based on expert opinion (Scheepers & Seebregts, 2006), the Willingness-to-Pay Index, which applies a cost-benefit analysis and examines what each country is willing to pay to minimize risk (Bollen, 2008). Other indices further include the Shannon-Wiener Index, which aims to capture diversification by considering the share of each commodity in the fuel mix (Bompard et al., 2017; Lo, 2011; Sun & Ren, 2021), the Herfindahl-Index, which assesses the concentration of suppliers of an energy commodity (Bompard et al., 2017). Similarly, the IEA's Energy Security Index analyses the impact of supply market concentration on energy commodity prices, incorporating the geopolitical risk rating of supplier countries.

Existing research on energy security and country risks has several limitations. One of the shortcomings is the lack of transparency and comparability of existing indices for measuring energy security as well as country risks, thereby restricting the ability to assess and compare countries. The assessment of country risks in a changing energy landscape and the impact of energy transitions on the energy security of energy import-dependent countries remains understudied. In addition, the interdependencies between energy security, geopolitics, and renewable energy sources are still not fully assessed, especially concerning future energy carriers like hydrogen and its derivatives. Further research is needed, particularly on the supply risks of hydrogen and its derivatives, as the geopolitical implications of global supply chains will play an important role in the context of the changing energy landscape.

This research adds to the existing literature by applying a transparent framework to assess potential future energy production performance. For the present analysis, the work of Muñoz et al. (2015) is taken as a primary reference, and the composition of the EFES follows the factor analysis method, which reduces the dimensionality of the data and identifies the factors influencing potential hydrogen exporters' performance. This study provides an overview of the performance of more than 80 countries over the period 2017 – 2021, taking political, economic, social, and energy-related factors into account.

3 Introducing the EWI Future Energy Score

3.1 Introduction to the sub-indicators and focus of the analysis

Conceptually, country risks are perceived as a result of political, social, and economic factors (Oetzel et al., 2001). Since political and economic events influence country risks, they affect energy trade as well (Zhang et al., 2021). In the literature and public discourse, country risks often focus on risks to profits and assets when investing in a country. Country risks are thereby not limited to state actors. However, when investing in a country, they may also arise from and affect non-governmental actors, including all kinds of societal, political, and business actors (Brown et al., 2015).

> *"Country risk can be broadly defined as the probability of particular future events within a state that could have an adverse effect on the functioning of a given organization (or, for that matter, an individual), whether that organization be a business, government agency, non-governmental organization (NGO), or other type of body" (Brown et al., 2015).*

In this study, the EFES is used to analyze country risks in hydrogen exporting countries from an importer's perspective. Since the EFES is focused on in-country conditions, transport risks are not considered. Four sub-indicators form the conceptual foundation of the EFES:

- **Political sub-indicator**: Various political factors can influence the stability and political situation in a country or region and, thus, the reliability of energy supplies like hydrogen. Political instability, weak and inefficient governance structures, and domestic, regional, and international conflicts pose a risk to reliable supplies. Political risks include internal and external conflict, terrorism, institutional and government instability, dysfunctional law and order, and control of corruption.
- **Economic sub-indicator:** Numerous economic factors influence the risk potential of energy production. The economic situation in a country impacts political and social stability and the development of future energy markets. A country's economic factors can be closely interwoven with global economic developments. Economic factors include

economic stability, economic growth and wealth, inflation, financial stability, and economic freedom.

- **Social sub-indicator:** Social factors are closely linked to the other sub-indicators. Various societal factors may foster social dissatisfaction. Socioeconomic dynamics and pressures in a society can challenge political and economic stability. Social inequality, tensions, and resource conflicts can lead to instability and pose a risk to stable and reliable energy production.
- **Energy sub-indicator:** Various energy-related factors determine the risk potential of future energy exports as part of a country's energy sector. Thereby, the current situation of a country's energy system and energy industry is relevant to the EFES. The energy intensity, the share of RES in the energy system, dependency on energy imports, experience in handling hydrogen or natural gas, investments in the energy sector, specifically in energy infrastructure, and R&D efforts influence the EFES. Climate policy, such as a CO_2 price, supports the cost competitiveness of low-carbon solutions.

In the following, the creation of the EFES is performed for all countries for which public data is available. The number of countries is determined by data availability and quality. Key findings are compiled for the best-performing countries to assess the results. Additionally, light is shed on countries with an official hydrogen partnership with Germany.

The German government relies on various formats for cooperation on energy and the energy transition, among others, focusing on green hydrogen. While several ministries are engaged in these activities, three different formats of bilateral cooperation are currently used:

- Energy and climate partnerships
- Energy dialogues
- Hydrogen partnerships

Energy dialogues form the preliminary stage of partnerships. Partnerships are based on an official "Joint Declaration of Intent". So far, the German government has established energy partnerships with 30 countries around the world.

Table 1: German hydrogen partnerships

1. Australia
2. Canada
3. Chile
4. Egypt
5. Morocco
6. Namibia
7. Saudi Arabia

Source: Own illustration

In addition to the energy partnerships, which focus on multiple different topics, among others also on hydrogen, dedicated hydrogen partnerships have been established with selected countries (see Table 1). These hydrogen partnerships are, until now, either the only form of energy cooperation between Germany and the partner country, as in the case of Namibia and Egypt, or are built up on top of existing energy cooperation. The latter is the case for the remaining five hydrogen partners. The list of hydrogen partnerships may grow in the future. All the current official partner countries differ from each other in multiple regards (see A.1 Overview of chosen hydrogen partnerships with Germany in the Appendix). Energy and hydrogen partnerships contribute to further expansion with renewable energies and thus help to become independent of (foreign) fossil fuels. Hydrogen can be produced worldwide, and the hydrogen partnerships, in particular, help diversify German hydrogen imports. In addition, partnerships support the establishment of sustainable supply chains. In a nutshell, energy and hydrogen partnerships help to build up international networks, share knowledge, and implement hydrogen projects, thereby contributing to ensure global energy security (Federal Ministry for Economic Affairs and Climate Action, 2023).

The official hydrogen partners are not the only potential hydrogen exporters relevant to Germany. However, as there appears to be a dedicated political will to cooperate with these states, among others, these countries will be examined in the course of this analysis.

3.2 The Principal Component Analysis

Various commonly used indicators appear in the literature on country risks, mainly addressing economic and financial risks (Kosmidou et al., 2008). The assessment also utilizes political data, and some draw on operational and social variables (Brown et al., 2015). This analysis makes the case for a broad assessment of a country's performance regarding investments and resulting hydrogen exports based on an integrated and holistic set of variables.

Data on country performance

Based on an extensive search of data, a dataset with a variety of variables capturing the situation in a country has been collected. This study extracted 128 variables, including 34 economic, 19 political, 31 social, and 44 energy-related (see A.2 in the Appendix for the extensive list of variables). Data used is provided by international organizations such as the World Bank Group, the International Monetary Fund (IMF), the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the Organisation for Economic Co-operation and Development (OECD), research institutes and private companies, e.g., the Heritage Foundation, Vision of Humanity, Transparency International, Freedom House.

While gathering data from 2000 until the most recent year available, only the last five years are considered in the final analysis (2017-2021). On the one hand, this limitation to 5 years is a reaction to missing data in earlier years and, on the other hand, is intended to focus on recent developments.

Due to data limitations for several variables and countries for the selected, various countries and variables could not be considered in the PCA.

Methodology to create country scores

The methodology is based on multivariate analysis. Multivariate analysis is a field that encompasses a range of statistical techniques that treat multiple correlated random variables as a single unit. This is done to produce comprehensive results while considering the relationships between the random variables. One of the most widely used multivariate analysis techniques is Principal Component Analysis (PCA). PCA method is a data-analytical technique that linearly transforms a group of correlated variables given that specific conditions are met (Jackson, 1991). It is used to create an index - here referred to as a score - by reducing the dimensionality of a dataset while retaining the maximum amount of information. It is commonly employed when dealing with a large number of variables that are potentially correlated.

The main underlying concept of PCA for sample data is as follows: consider a matrix Y that is composed of n observations and p variables, such that there is a considerable correlation between the variables p. Therefore, without losing much information, the data can be represented in $q \ll p$ dimensions, where q represents the new variables after data reduction. In other words, PCA replaces the original p variables with q linear functions of those variables. The coefficients in these linear functions are selected given that they maximize the sum of the variances of the q new variables (Jolliffe, 2002, 2022). A more formal explanation and the formal description of the PCA is given in section A.3 in the Appendix.

The model that PCA uses can be interpreted as follows:

$$y_{ij} = a_i' b_j + e_{ij} \qquad i = 1, \ldots, n \qquad j = 1, \ldots, p$$

where y_{ij} are elements of matrix Y, a_i are scores and b_j are loadings, and together they form **q**-vectors of parameters. Independent homoscedastic residuals are assumed and referred to by e_{ij}. The $E(Y)$ is a matrix of rank q, where $q \ll p$.

The main steps followed under this approach are as follows:

1. Gathering the relevant variables related to the concept that is being investigated and data pre-processing, such as variable standardization and/or normalization.
2. Computing the correlation matrix based on the data, which provides information about the relationships between the variables.
3. Calculating the eigenvalues and eigenvectors of the correlation matrix, where the eigenvalue represents the amount of variance explained by each eigenvector.
4. Selecting eigenvalues that explain the majority of the data variance, where eigenvalues correspond to the principal components that capture the most significant patterns in the data.
5. Calculating component scores by projecting the original data onto the selected principal components, where the standardized data is multiplied by the eigenvectors.
6. Combining component scores to form the sub-indicators and the EFES.

The initial variable list included 128 variables for 166 countries. Due to missing data for the period under consideration, some variables and countries are omitted. The selection process of the variables is based on examining correlations to identify possibly excessive variables because of their weak correlations with the rest of the variables list.

The Kaiser-Meyer-Olkin (KMO) test is implemented to test sample adequacy by examining the correlations and partial correlations between the variables. Having relatively low partial correlations compared to the correlations leads to a high KMO value, hence the possibility of achieving a low-dimensional representation of the data.

Another factor considered in PCA is the number of components to keep for every sub-indicator, where we set a minimum of 70 % of variance to be accounted for by the first q components (see Table 2).

Table 2: Variable selection

Sub-indicator	Final number of variables	Kaiser-Meyer-Olkin (KMO)	Total variance %
Political	10	0.90	85.27
Economic	13	0.72	81.25
Social	5	0.68	73.80
Energy	9	0.70	70.78

Source: Own calculations

In addition, the measure of squared multiple correlation (SMC) is estimated as a secondary measure to determine if any of the variables are worthy of exclusion. If the SMC value of a variable is small, this indicates that it cannot be well-interpreted from the rest of the variables.

The previously introduced criteria are implemented in an iterative process to achieve an appropriate sample. It is important to highlight that PCA is implemented for each sub-indicator independently (economic, energy-related, political, and social). Then, the four sub-indicators are aggregated with equal weights into a single EFES.

4 Key findings and rankings: Assessing potential hydrogen exporters

This analysis uses a PCA to create scores for countries worldwide. Table 3 displays the countries by region included in the final analysis.

The EFES is based on the four sub-indicators of the political, economic, social, and energy sub-indicators. The results may vary for each country by year. Each sub-indicator displays results for each country's performance, resulting in a different country ranking for each sub-indicator, as a country may perform better or worse in different sub-indicators.

Table 3: Countries included in the analysis by region

Region	Countries
Africa	Angola, Benin, Botswana, Cameroon, Ghana, Madagascar, Mozambique, Namibia, Niger, Senegal, South Africa, Togo, Uganda
Americas	Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, United States[1]*, Uruguay
Asia-Pacific	Australia, Bangladesh, Cambodia, India, Indonesia, Japan, Kazakhstan, Malaysia, New Zealand, Pakistan, Philippines, Singapore, South Korea*, Sri Lanka, Taiwan, Thailand, Turkey, Vietnam*
European Union (EU)	Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg*, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia*, Spain, Sweden
Non-EU Europe	Albania, Bosnia and Herzegovina, Georgia, Iceland, Macedonia, Norway, Russia, Switzerland, Ukraine, United Kingdom
MENA-Region	Algeria, Bahrain, Egypt, Israel, Kuwait, Morocco, Oman, Qatar, Saudi Arabia, Tunisia

Source: Own illustration

The score ranks between 0 and 100. The higher a country's score, the better it performs. The analysis has been conducted for the years 2017 to 2021. Due to missing data for all included countries, a score for each year is not available. In the following, the analysis's results will be displayed by first discussing the results of the four sub-indicators and second assessing the final EFES (see A.4 in the Appendix for the entire results).

4.1 Political sub-indicator

Countries worldwide possess renewable energy potentials, and several states aim to exploit these potentials to become hydrogen suppliers in the future. However, various countries find themselves in geopolitical or domestic conflicts, posing a security deficit. Political risks such as political instability and policy changes can result in economic losses for businesses and investors. For establishing secure hydrogen supply chains, low political risks are important. Therefore, countries with a high political sub-indicator may pose lower investment risks and a more secure supply.

Table 4 shows the political variables, which are divided into two clusters reflecting the political performance of the countries. The first cluster describes the country's political stability and

[1] Countries for which no country score is available are indicated by a star (*) For these countries at least one of the four dimensions could not be quantified due to data constraints.

institutional performance, and the second cluster provides information about the impact of terrorism in a country.

Table 4: Variables and clusters of the political sub-indicator

Sub-indicator	Cluster	Variables (incl. relation +/-)
Political sub-indicator	Political stability and institutional performance	Global Peace Index (+), Government Effectiveness Index (+), Political Stability (+), Corruption Perception Index (+), Regulatory Quality (+), Fragile State Index (+), Voice Accountability Index (+), Political Rights Rating (+), Civil Liberty Rights Rating (+)
	Impact of terrorism	Global Terrorism Index (-)

Source: Own illustration

Figure 1 shows the political sub-indicators of countries worldwide in 2021. The average score of the political sub-indicator is 48. Here, the discrepancy between the highest and lowest scoring countries is in a range of 14 to 79 highly pronounced.

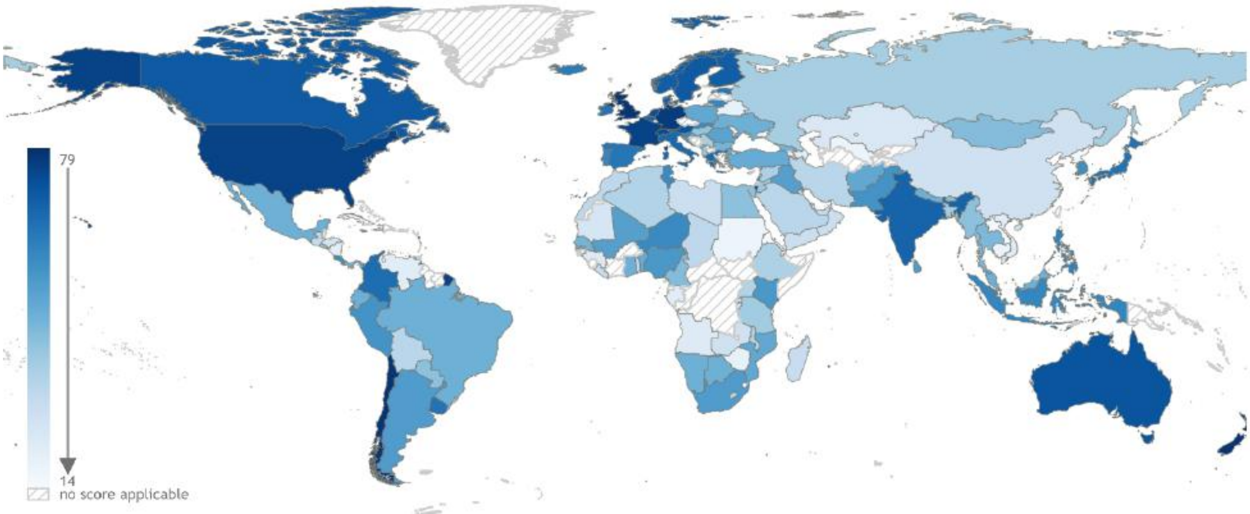

Figure 1: Map of the political sub-indicator 2021

Source: Own illustration

Frontrunners in the political sub-indicator

The United Kingdom, New Zealand, Chile, Germany, France, and the United States are the highest-scoring countries, with political sub-indicators ranging from 77 to 79 (see Table 5). All countries are high-income, considered part of the Western world, and have a stable political environment, strong institutions, and a liberal economy.

Table 5: Countries with highest political sub-indicator

Country	Political score
United Kingdom New Zealand Chile	79
Germany	78
France Unites States	77

Source: Own calculations

As the gap in the political sub-indicator between the frontrunners and the weakest-performing countries is significant, the major potential for improvement for the countries scoring the lowest remains. A significant improvement in the humanitarian situation, living conditions, and business environment would lead to a higher political sub-indicator and, thus, a lower political risk.

Political sub-indicator of countries with hydrogen partnerships with Germany

Figure 2 displays the political sub-indicator for countries with which the German government established hydrogen partnerships. The hydrogen partnership countries perform differently in the political sub-indicator. Three groups appear: Canada, Australia, and Chile reach a score of over 70, Namibia and Egypt score above 45, while Morocco and Saudi Arabia score below 40. While Chile's score increased in 2021 and Namibia remained, the others' political sub-indicators declined in 2021.

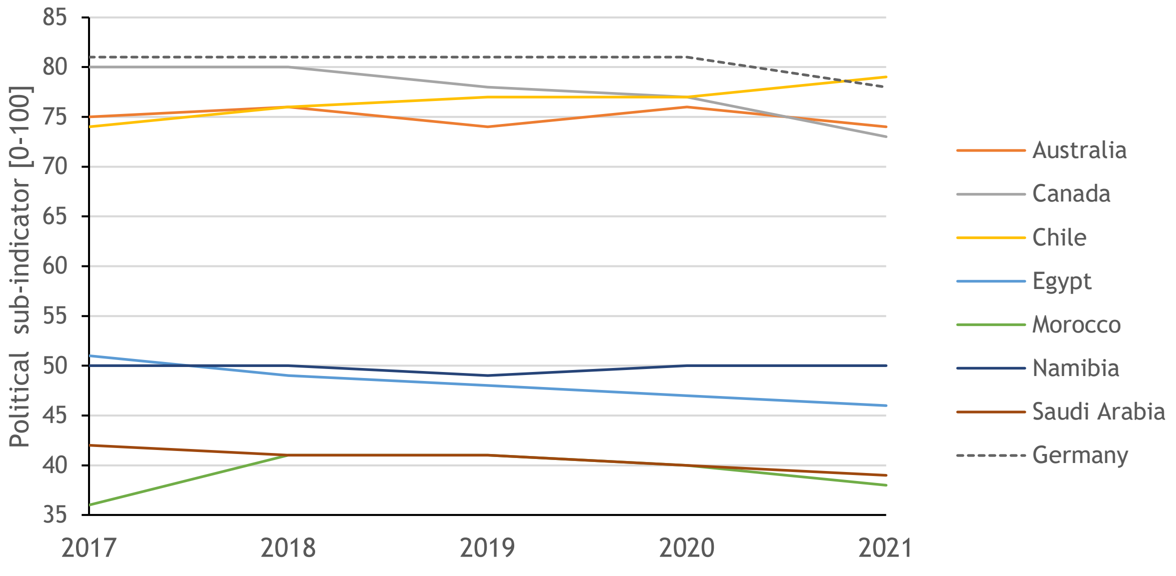

Figure 2: Political sub-indicator of Germany's hydrogen partners

Source: Own calculations

Despite its high political sub-indicator, Canada has seen a decline in its score since 2018. In part, the unresolved discrimination against the indigenous population in the country may explain this development. Access to clean drinking water is not guaranteed on all reserves, and indigenous people face insufficient support to adapt to current and future climate change impacts (Human Rights Watch, 2022a).

The weaker and declining political sub-indicators of Morocco and Saudi Arabia could be partly explained as Morocco's political system is considered partially free and Saudi Arabia's system as not free (Freedom House, 2023b, 2023c). In Morocco, NGOs criticize restrictions on freedom of expression, assembly, and the press (Federal Ministry for Economic Cooperation and Development, 2023b). Such restrictions also apply to Saudi Arabia (Human Rights Watch, 2022b). Additionally, the conflict between Morocco and Algeria over the Western Sahara intensified recently (Deutsche Welle, 2023).

4.2 Economic sub-indicator

Besides the political situation in a country, its economic and financial situation determines its attractiveness for businesses and investors, the costs and competitiveness of hydrogen projects, and its bankability. An unstable economic situation significantly increases the risk of future political and social instability in a country. For the creation of stable, long-term hydrogen supply chains, low economic risks are relevant for the business case, but also for secure supply chains. In the following, the economic sub-indicator for countries is outlined. A high economic sub-indicator can be read as low economic risks.

The economic variables are grouped into 4 clusters, as shown in Table 6, which exhibit countries' economic performance. The variables are clustered to reflect the country's level of foreign trade and investment, trade and economic growth, economic stability, and business environment, as well as state liquidity.

Table 6: Variables and clusters of the economic sub-indicator

Sub-indicator	Cluster	Variables (incl. relation +/-)
Economic sub-indicator	Foreign trade and investment	Foreign Direct Investment (FDI) inflows (+), FDI outflows (+), exports (+), imports (+)
	Trade and economic growth	Export growth (+), import growth (+), GDP per capita growth (+)
	Economic stability and business environment	Export Quality (+), Economic Freedom (+), Financial Development (+), GDP per capita (+)
	State liquidity	Balance of Payments – current account (+), Balance of Payments – financial account (+)

Source: Own illustration

Figure 3 shows the economic sub-indicator for countries worldwide in 2021. Hereby, the country results range from 37 to 72. On average, countries reach a score of 49.

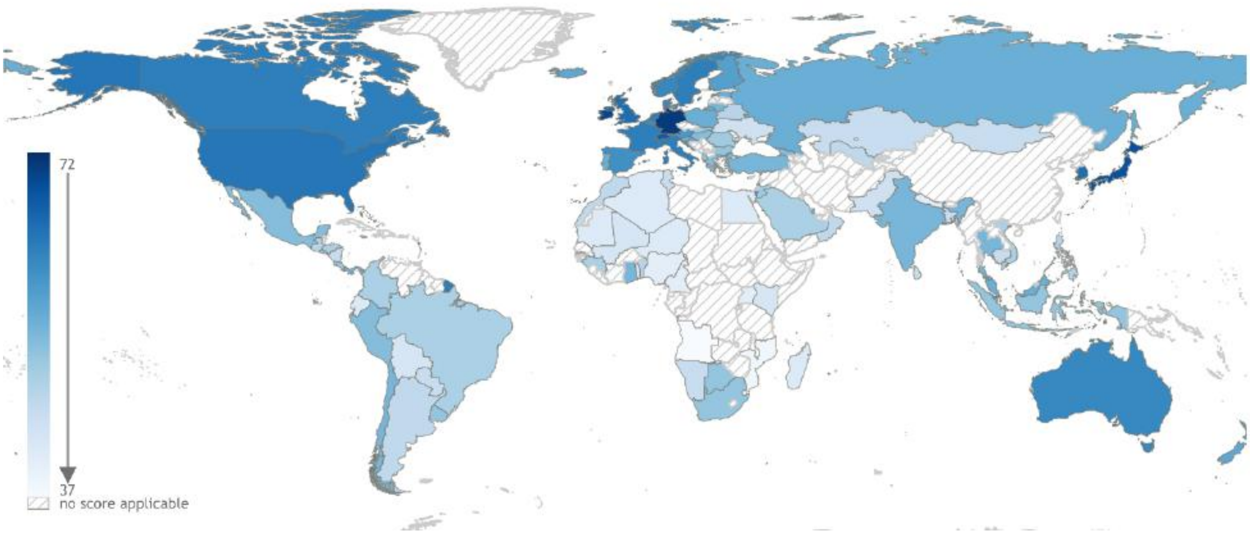

Figure 3: Map of the economic sub-indicator 2021

Source: Own illustration

Frontrunners in the economic sub-indicator

The top-performing countries in the economic sub-indicator 2021 are Germany, Ireland, Singapore, Japan, and Switzerland, reaching a score between 63 and 72 (see Table 7). The best-performing countries on the economic sub-indicator are highly developed and industrialized countries located in Western Europe and East Asia.

Table 7: Countries with highest economic sub-indicator

Country	Economic Score
Germany	72
Ireland Singapore	65
Japan	64
Switzerland	63

Source: Own calculations

The analysis displays a relatively large gap between the best and weakly performing countries in the economic sub-indicator. While weakly performing countries are not lacking that far from the average of 49, this indicates a smaller number of well-performing countries in the economic sub-indicator, driving the average up.

Economic sub-indicator of countries with hydrogen partnerships with Germany

Figure 4 displays the economic sub-indicator of countries having a dedicated hydrogen partnership with Germany. The results of the economic sub-indicator for the selected hydrogen partners are more fluctuating compared to the political sub-indicator. For all countries, changes over the years are visible. While Egypt's economic sub-indicator improved slightly in 2021 compared to 2020, the country nevertheless showed the weakest performance among Germany's hydrogen partnership countries in 2021. The country's economic sub-indicator has significantly declined since 2017, which can be considered as increased economic risks. In contrast, Canada and Australia clearly achieved the highest results in the economic sub-indicator from 2017 to 2021.

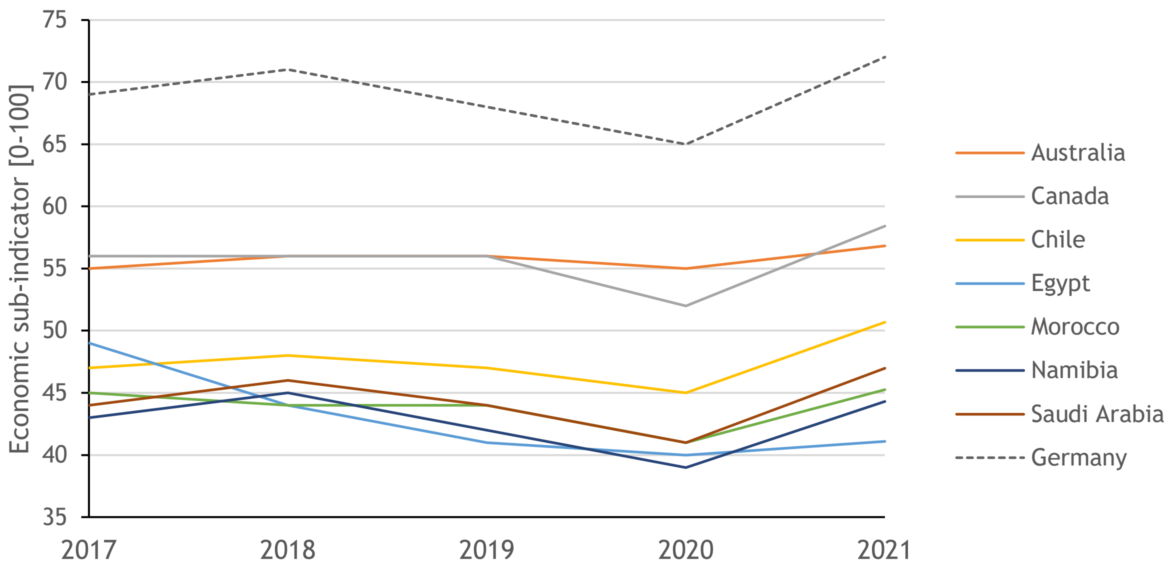

Figure 4: Economic sub-indicator of Germany's hydrogen partners

Source: Own calculations

The economic sub-indicator of countries with dedicated hydrogen partnerships with Germany experienced a noticeable drop in the year 2020, which can be translated into higher economic risks in the selected countries. This drop in countries' economic performance is related to the negative economic consequences of the COVID-19 pandemic. In 2021, the score of all selected German hydrogen partner countries has recovered, with Chile, Canada, and Saudi Arabia improving quickly and strongly.

4.3 Social sub-indicator

In addition to the political and economic sub-indicator, a country's social situation is an important determinant of its attractiveness as a potential hydrogen supplier. The social conditions in a country are closely connected with its political and economic situation. Social stability, comprising aspects such as the overall quality of life, social cohesion, health, and education, plays an important role in determining a country's prospects. Capitalizing on renewable energy potentials to become a hydrogen supplier entails potential social challenges, such as local conflicts over resources, particularly water.

The social variables form two clusters (see Table 8) displaying a country‘s social performance. The selected variables are clustered to reflect, first, the living conditions the population faces in a country and, second, the water resilience of a country, as this is a major input for hydrogen production. The availability of water resources plays a crucial role in hydrogen production. Therefore, in cases where a country suffers from water stress, the social risks are exacerbated, making hydrogen production more challenging.

Table 8: Variables and clusters of the social sub-indicator

Sub-indicator	Cluster	Variables (incl. relation +/-)
Social sub-indicator	Living conditions	Access to electricity (+), population growth (-), Human Rights (+), Human Development Index (+)
	Water resilience	Water stress (-)

Source: Own illustration

Figure 5 illustrates the social sub-indicator for 2021. Results are ranging from 44 to 95 and show a high discrepancy. The average of the social sub-indicator is 75.

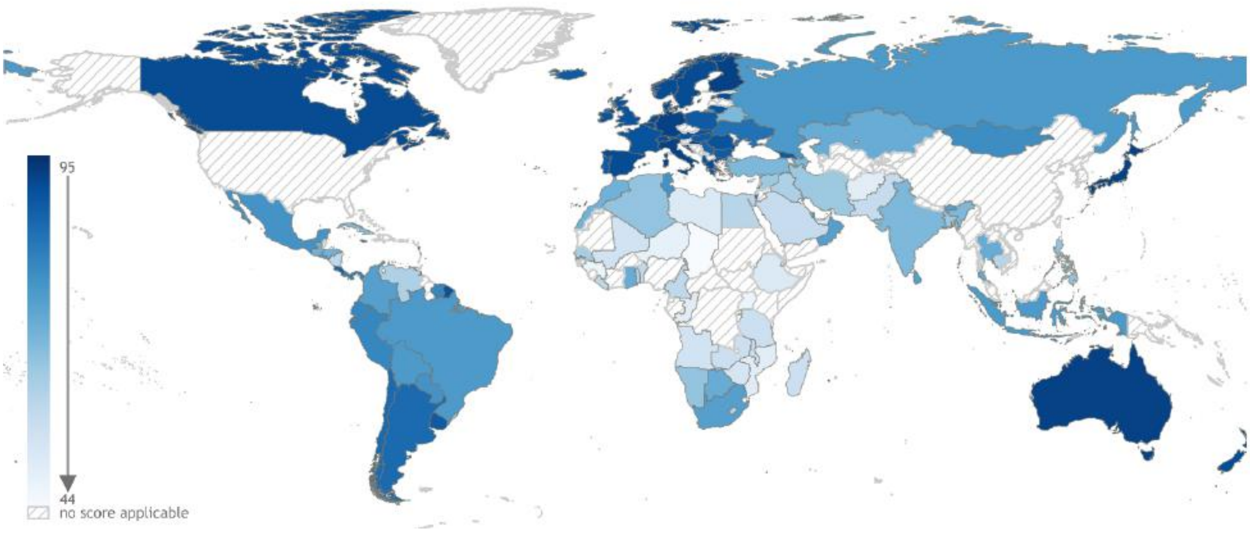

Figure 5: Map of the social sub-indicator 2021

Source: Own illustration

Frontrunners in the social sub-indicator

Croatia, the Czech Republic, and Latvia reached 90 or higher, the highest social sub-indicator (see Table 9). The five countries, Australia, Finland, Germany, Italy, and Japan, follow, scoring 89. The highest-scoring countries in the social sub-indicator are all Western, democratized, and highly developed nations.

Table 9: Countries with highest social sub-indicator

Country	Social Score
Croatia	95
Czech Republic	92
Latvia	90
Australia Finland Germany Italy Japan	89

Source: Own calculations

Several countries performing weakly in the social sub-indicator are also strongly affected by climate change (World Bank, 2023c, 2023e, 2023g). This poses a significant challenge to already vulnerable societies.

When public institutions struggle or lack secure access to basic resources and services, such as electricity, water, or education, this may also undermine a country's political and economic stability.

Social sub-indicator of countries with hydrogen partnerships with Germany

Figure 6 displays the development of the social sub-indicator for Germany's official hydrogen partner countries. Again, three groups can be identified with the same best-performing countries as in the political sub-indicator, scoring above 80: Australia, Canada, and Chile. Morocco and Namibia range in the middle, and Saudi Arabia and Egypt, with 61 performing the weakest among the hydrogen partners.

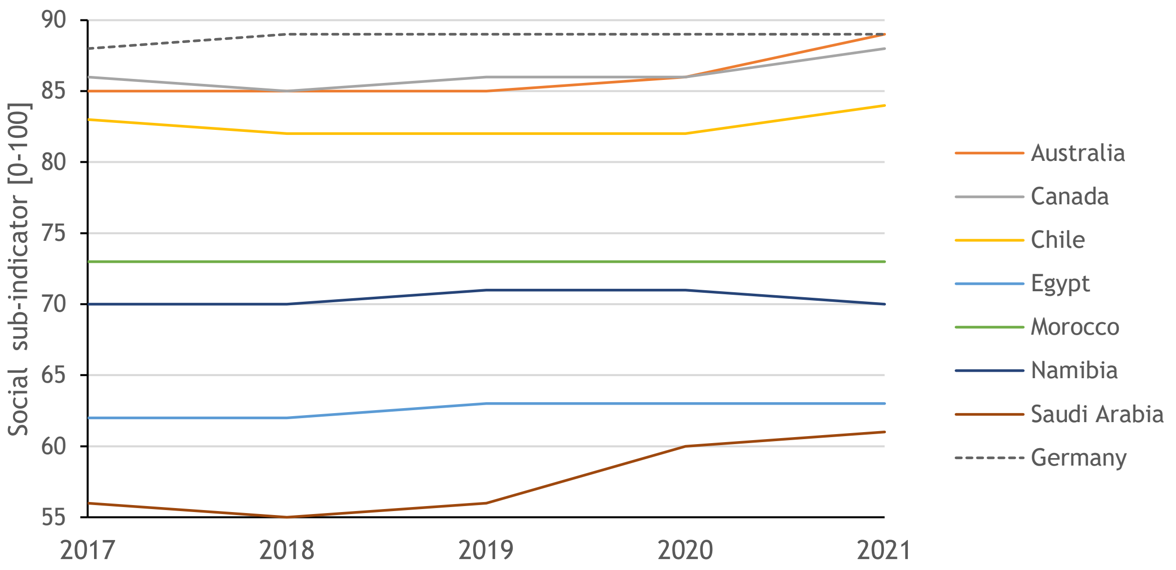

Figure 6: Social sub-indicator of Germany's hydrogen partners

Source: Own calculations

In Egypt, one-third of the population lives below the national poverty line. Most income is generated in the informal sector, which is why the majority of the population has no access to public benefits. As a consequence of the pandemic, child labor in agriculture has increased. Living conditions in the cities are poor due to massive environmental problems. However, extensive development efforts are aimed at rural regions, including expansion of infrastructure, offering the potential for future improvement of the situation (Federal Ministry for Economic Cooperation and Development, 2023a).

Namibia scores 70 in 2021 but is the only country showing a slightly decreasing social sub-indicator since 2020. This could be because of poverty rates still exceeding pre-pandemic levels. In particular, two-thirds of the population lack access to basic sanitation, more than 20 % are malnourished, and only half have access to electricity. Moreover, Namibia is characterized by high levels of inequality, as only a small portion of the population benefits from economic progress, resulting in a dual economy with a highly developed modern sector and an informal subsistence-oriented sector (Federal Ministry for Economic Cooperation and Development, 2023c; World Bank, 2023h). This challenges the development of a sustainable hydrogen economy in Namibia, with major responsibilities for political decision-makers.

4.4 Energy sub-indicator

In addition to the political, economic, and social sub-indicators, a country's energy situation is a key aspect determining a country's suitability and potential stability as a green hydrogen supplier. Besides the central factors such as renewable energy potential, the capacity factor, and thus the costs of renewable energies, which are considered in hydrogen cost assessments, various additional factors are relevant to analyze a country's potential as a reliable hydrogen supplier.

Countries with existing natural gas export infrastructure have an advantage as this not only reduces the initial infrastructure investment costs but also entails the benefit of a skilled labor force with experience in the handling of gases. As hydrogen production via electrolysis demands vast amounts of electricity, the risk of local competition for hydrogen exports arises. Therefore, countries with major energy resources and self-sufficiency well equipped to meet their future energy needs might be advantageous green hydrogen suppliers if they manage to decarbonize their energy production.

The energy sub-indicator does not measure the sustainability of a country's energy system but rather encompasses indicators aiming to measure a country's energy resilience. These factors include energy infrastructure, sustainable practices, resource availability, and energy exports. Energy policies, R&D efforts, planned renewable energy projects, and investments are not included in this analysis due to data restrictions. Thus, the energy sub-indicator reflects the current status of a country's energy system. Based on available data and the PCA analysis, a high-energy sub-indicator can be read as low energy-related risks.

The variables of the energy sub-indicator have been grouped into three clusters (see Table 10). The variables are clustered to reflect the country's level of energy production and share of fossil exports, renewable energy production, and its security of supply of non-renewable energy.

Table 10: Clusters of the energy-related risk variables

Sub-indicator	Cluster	Variables (incl. relation +/-)
Energy sub-indicator	Energy production and fossil fuel export	Energy production (+), natural gas production (+), natural gas export (+), oil exports (+)
	Renewable energy sources	Share of renewable energy supply (+), electricity production from renewable energy sources (+)
	Security of supply of non-renewable energy	Natural gas imports (-), oil reserves (+), oil self-sufficiency (+)

Source: Own illustration

As Figure 7 illustrates, the energy sub-indicator for 2021 ranges between 24 and 75. The average score in the energy sub-indicator is 33.

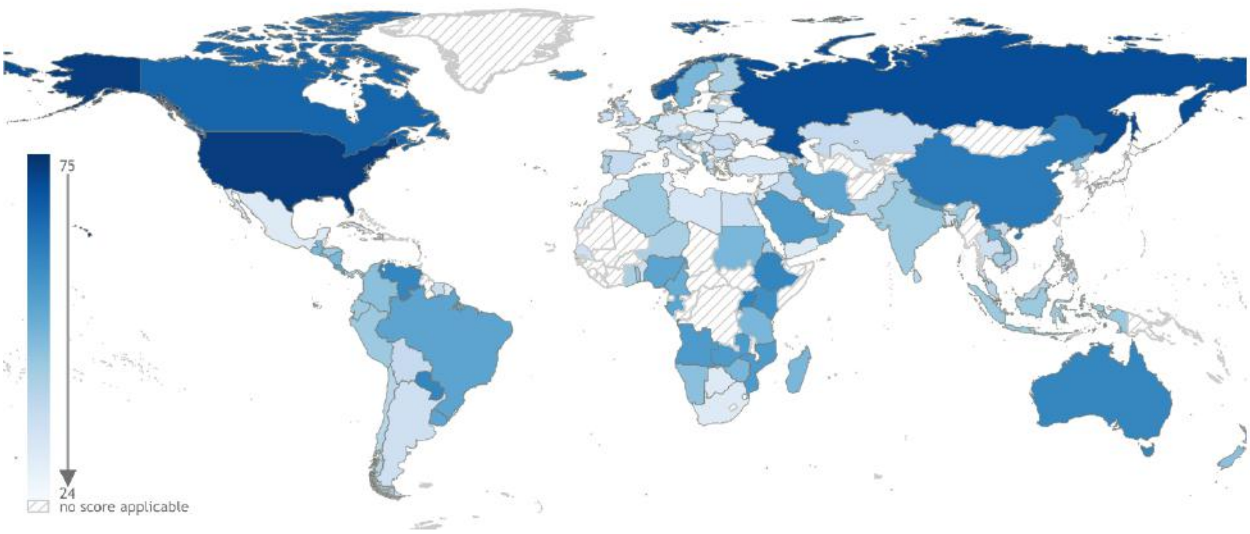

Figure 7: Map of the energy sub-indicator 2021

Source: Own illustration

Frontrunners in the energy sub-indicator

The countries with the highest energy sub-indicators in 2021 are, by far, the United States (US) and Russia, with a score greater than 70, followed by Norway, Canada, and Qatar, scoring between 50 and 43 (see Table 11). The top-performing countries possess abundant fossil energy resources and are major energy producers across various energy carriers.

Vast oil, natural gas, and coal reserves are located in the US, Russia, and Canada. Norway profits from its hydroelectric potential in addition to its significant oil and gas reserves in the North Sea, while Qatar is one of the world's largest natural gas producers. These countries are net energy exporters (IEA, 2023c), equipped with dedicated experience, export infrastructure, companies, and networks.

Endowed with significant energy resources and producing a large share of their energy domestically, these countries have an advantage over countries heavily dependent on energy imports to meet domestic demand. As characterized by being energy self-sufficient, it is more likely to be an energy exporter or, more precisely, a potential hydrogen exporter. The ability to export fossil fuels is one factor that contributes to being energy self-sufficient.

Table 11: Countries with highest energy sub-indicator

Country	Energy Score
United States	75
Russia	72
Norway	50
Canada	47
Qatar	43

Source: Own calculations

The top-performing countries possess advanced technologies for energy extraction, production, and distribution and a well-developed and well-maintained energy infrastructure. This infrastructure increases the reliability of energy supplies. In the case of gas infrastructure, this forms a significant advantage for the production and export of green hydrogen, as infrastructure can be retrofitted and skilled labor is available, so economies of scale become rapidly realizable.

Beyond their fossil energy resources, these top-performing countries in the energy sub-indicator also have significant renewable energy potential. Their geographical diversity allows them to tap wind, solar, hydro, and other renewable sources (e.g., biomass). Their significant reserves and major energy production, while being a net exporter, reduce the risk of competition of hydrogen exports with domestic demand. Nevertheless, all of these top-performing countries, with Norway being the only exception, face the major challenge of decarbonizing their energy production to become stable green hydrogen suppliers. If these countries succeed has to be seen, their decarbonization process and economic restructuring may face opposition from fossil fuel interest groups.

Energy sub-indicator of countries with hydrogen partnerships with Germany

Figure 8 illustrates the energy sub-indicator of the countries with which the German government has officially established hydrogen partnerships from 2017 to 2021. Canada is the only country with an energy sub-indicator above 40 from the hydrogen partners. Australia, Saudi Arabia, Namibia, and Chile have scores exceeding 30. Morocco and Egypt scored below 30. As the energy sub-indicator incorporates different factors related to renewable energy sources but also fossil fuels, the reasons for the performance of countries vary.

Canada scores the highest among the partner countries. Hydropower as a technology makes up the largest share of electricity production in Canada. Thus, hydropower positively influences the energy sub-indicator in two ways: firstly, through its large share in total energy production and secondly as renewable energy representing a major share of the total electricity generation from renewables in the country. The recent increase in Canada’s energy sub-indicator may be attributed to the ongoing expansion of renewable energy sources.

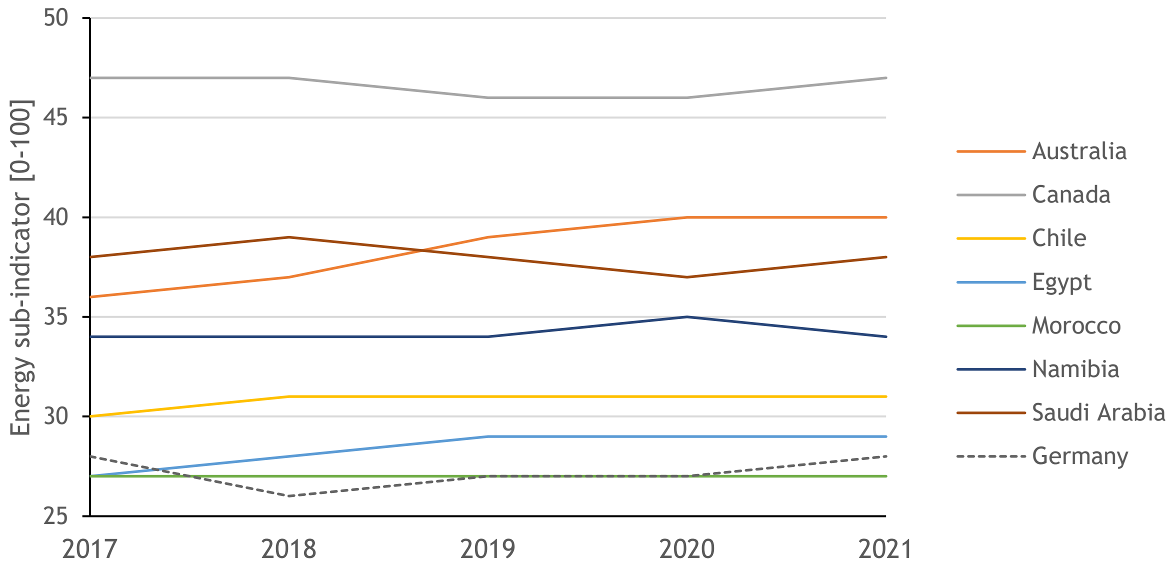

Figure 8: Energy sub-indicator of Germany's hydrogen partners

Source: Own calculations

Although Australia and Saudi Arabia reach similar results in the energy sub-indicator, their energy system differs significantly. While Saudi Arabia's electricity production predominantly relies on fossil fuels, Australia's energy mix is more diverse.

Chile's energy sub-indicator has been constant since 2018 despite continuous expansion with renewables since 2016. With 47 %, fossil fuels still account for a major share of the country's electricity mix.

Namibia generates the lowest amount of total electricity among the German hydrogen partner countries. The country has a significant share of renewable energy production, with 96 % of total energy production (TEP) coming from renewables, mainly hydropower. The recent decline in Namibia's energy sub-indicator can be linked to a slightly decreasing share of renewable energy production and a slightly increasing share of fossil fuel electricity generation.

Egypt's comparatively low energy sub-indicator can be linked to a high share of fossil fuels, specifically 89 % of the total energy production, of which 66 % is natural gas. Additionally, the expansion of renewables is stagnating and, since 2021, even slightly decreasing (Ritchie et al., 2022).

4.5 EWI Future Energy Score

Each of the four sub-indicators reflects a central piece of the puzzle, contributing to the question of which potential green hydrogen exporters may be attractive for building secure supply chains. An integrated perspective enables a comprehensive evaluation of a country's potential as a stable hydrogen supplier. Here, the assessment of an EFES encompasses the combination of the previously presented results of the four sub-indicators: political, economic, social, and energy.

All four sub-indicators are equally weighted, contributing 25 % to the EFES[2]. As countries performed differently in the various sub-indicators, the EFES allows a broader, multifaceted perspective.

Figure 9 displays the EFES for 2021. The EFES ranges from 40 to 67 in 2021 for the countries included in this analysis, averaging at 54.

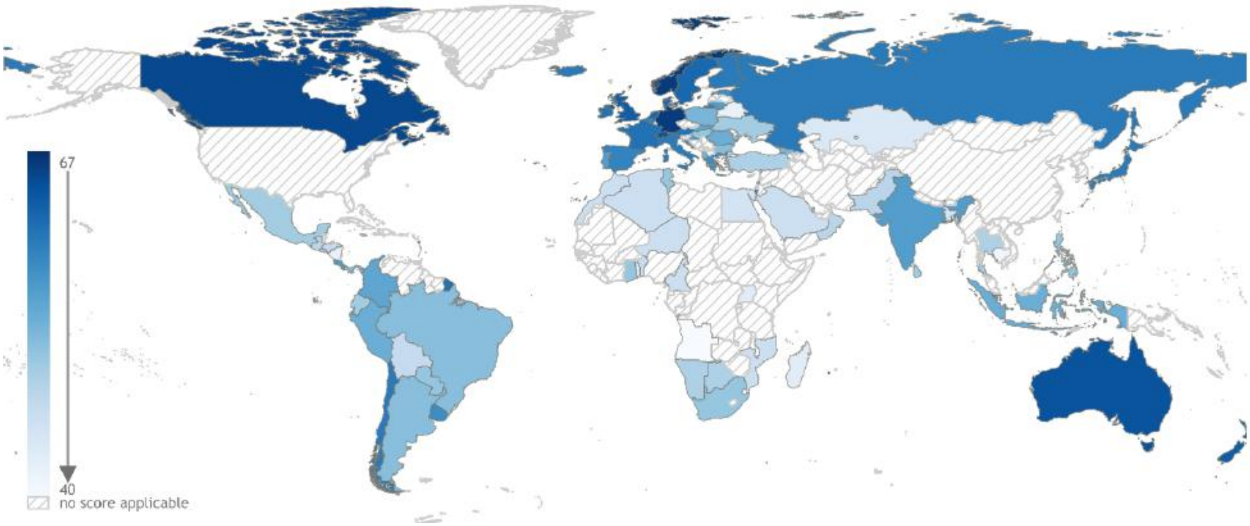

Figure 9: Map of the EWI Future Energy Score for 2021

Source: Own illustration

Frontrunners in the EWI Future Energy Score

Norway, Germany, Canada, Australia, Switzerland, New Zealand, and the United Kingdom (UK) are the frontrunners, all scoring between 64 and 67 (see Table 12). These scores reflect their overall strong performance in the various sub-indicators.

Norway is among the top scorers in the energy sub-indicator (4th) and ranks among the top 20 in the political (17th), social (17th), and economic (18th) sub-indicators. In addition, Norway has several advantages not directly captured in the EFES, such as its immense renewable energy potential, geographical proximity to Germany, and an established gas infrastructure between Germany and Norway. Norway also has good political and economic ties with Germany, underpinned by Norway being part of the EU's single market through the European Economic Area (EEA) agreement.

[2] The transparent presentation of the results in Appendix A.4 enables the calculation of own weightings and can be aligned with the goals of different stakeholders.

With an EFES of 66, Canada shows a robust profile among the top 15 countries in each sub-indicator. In line with Norway, Canada performs well in the energy sub-indicator. The potential for renewable energy generation from hydropower, as well as a considerable growth in wind and solar facilities, is particularly high in Canada, making the country suitable for producing green hydrogen. Besides the prerequisites for sustainable energy production, the country has already prepared for green hydrogen production by planning the necessary infrastructure. Furthermore, Canada's strong diplomatic ties with Germany create a favorable environment for energy cooperation. Nevertheless, while the alliance between Germany and Canada opens doors for cooperation, it is important to note that the logistics of transporting green hydrogen and its derivatives from Canada to Germany will require maritime transport.

Table 12: Countries with highest EWI Future Energy Score

Country	Country Score
Germany Norway	67
Canada	66
Australia Switzerland	65
New Zealand United Kingdom	64

Source: Own calculations

Switzerland and Australia both attain an EFES of 65, reflecting their different strengths and respective constraints concerning their position in the international energy market. Switzerland, on the one hand, excels in the economic and political sub-indicators, but its reliance on energy imports limits its energy sub-indicator to 32 (Schweizerische eidgenossenschaft, 2023). Nevertheless, Switzerland already generates most of its electricity from renewable energy sources, mainly hydropower. Still, it has untapped potential in solar energy to cover the country's entire energy demand by means of renewables in the future (Sachs, 2020). Australia, like Switzerland, achieves an EFES of 65, signaling its resilience and steady progress since 2017, even in the face of pandemic-related challenges. Australia's impressive stability in the economic sub-indicator is particularly noteworthy compared to other countries in 2020. Australia performs well in the social, energy, and political sub-indicators, particularly in the social sub-indicator, ranking fifth in 2021. However, direct hydrogen transport logistics may be challenging, given the considerable distance between Australia and Germany. As a result, Australia may play a more important role in importing hydrogen derivatives as part of the evolving global energy landscape.

New Zealand and the United Kingdom both score 64 points in 2021. New Zealand distinguishes itself with leading scores in the political sub-indicator (1st) and strong social performance among the top 10. Meanwhile, the UK stands out in the economic and political sub-indicators, although it is slightly below average in the energy sub-indicator. While New Zealand excels in political and social aspects, long transport routes pose a challenge for exporting hydrogen and its derivatives. In contrast, the UK benefits from its proximity to Germany and the EU when it comes to exporting green commodities - such as hydrogen.

Nevertheless, room for improvement remains for the top-performing countries. Notably, Switzerland, Germany, and the United Kingdom are scoring below average in certain areas. Meanwhile, the countries at the lower end of the EFES distribution face the challenge of making significant progress in the social and political sub-indicators.

EWI Future Energy Score of countries with hydrogen partnerships with Germany

Looking at the countries having an official hydrogen partnership with Germany, Canada and Australia reach the highest scores, with 66 and 65, respectively. Canada and Australia are closely followed by Chile, with an EFES of 61 in 2021 (see Figure 10).

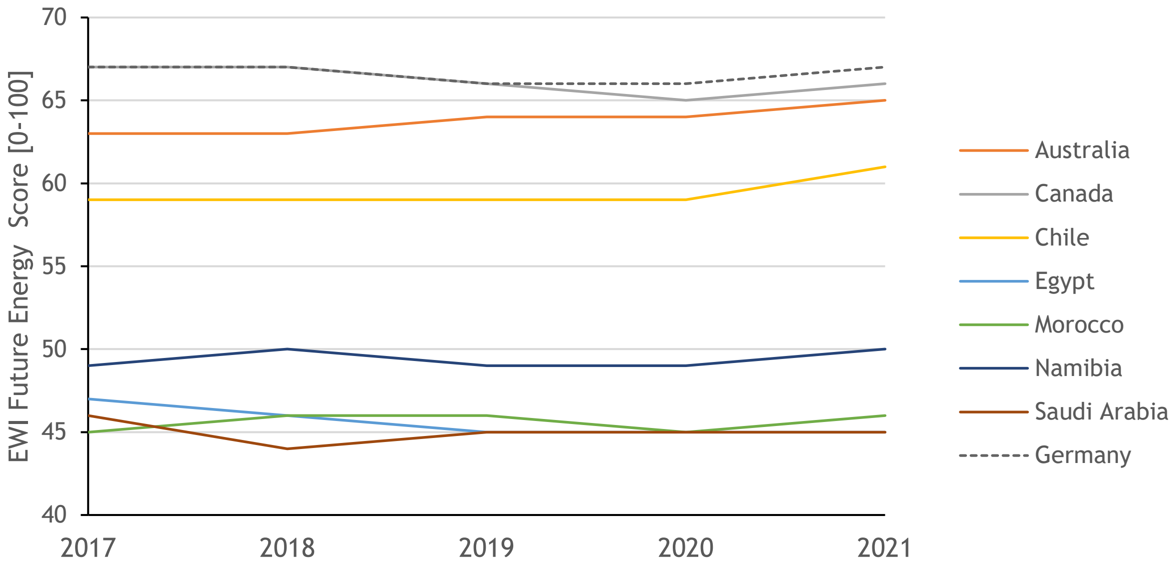

Figure 10: Country score of Germany's hydrogen partners

Source: Own calculations

As the analysis shows, Canada and Australia are both among the top performers worldwide in the EFES. From a strategic standpoint, to mitigate risks to Germany's energy security, a hydrogen partnership and cooperation on developing hydrogen value chains with both countries is a very logical step. In addition, Germany has good (political) relations with Canada and Australia, and both countries own vast renewable energy potentials. However, particularly for Australia, the associated costs and risks for long-distance transport have to be considered.

The hydrogen partner Chile particularly performs well in the social and political sub-indicator, which might initially appear surprising due to the country's political and social protests starting in 2019. Nevertheless, the country performs comparatively well in the currently considered aspects, offering a conducive precondition for a solid trading partnership. The country has major potential to produce renewable energies, especially from wind and solar, as its potential exceeds the country's energy demand by a factor of 70. The EU is also already financially supporting numerous hydrogen projects in the country. Due to the long transport route, Chile relies on the export of hydrogen derivatives (Boddenberg, 2023).

The EFES of the remaining hydrogen partnership countries are below the average EFES of all assessed states. Namibia reached an EFES of 50, performing above average in the energy and political sub-indicator and slightly below average in the economic and social sub-indicator. The enormous potential for producing renewable energy from solar and wind power, combined with its location on the Atlantic coast, a vast uninhabited land area, a well-developed road network, and political stability, make Namibia a suitable location for the production of green hydrogen, and an applicable trading partner. The country is a frontrunner for green hydrogen production in Africa. Germany and Namibia are planning one of the fifth largest hydrogen projects based on an investment volume equivalent to Namibia's GDP. However, the scarcity of water and the long transport routes form a challenge to the market ramp-up in Namibia (Russmann, 2023).

Morocco (46), Saudi Arabia (46), and Egypt (45) all rank in the EFES closely behind Namibia. The three hydrogen partner countries are all located in the MENA region. Despite differences between these countries, e.g., regarding their endowment with fossil fuel reserves, their performance in the energy sub-indicator, the economic situation – particularly the GDP per capita – and the performance of the economic sub-indicator, as well as political differences, these countries share several commonalities. They all have a high potential for renewable energy production. However, these countries face, among other things, political tensions in their region or with neighboring countries, resulting in partially similar challenges.

Among the countries with official hydrogen partnerships with Germany, only Morocco has the perspective of transporting green hydrogen through pipelines to Europe and potentially via Spain and France to Germany. This may significantly reduce hydrogen supply costs from Morocco, giving the country a cost advantage. While the EastMed project aimed to connect Middle Eastern countries via Cyprus and Greece with Europe and offered an opportunity to Egypt, the project was demised in 2021 due to technical and commercial reasons (Elgendy, 2022).

The hydrogen partnerships with these diverse countries offer the potential for mutual benefits and collaboration in establishing green hydrogen supply chains.

5 Outlook

The demand for green hydrogen and hydrogen-based products in Germany is expected to increase significantly to reach climate neutrality. Germany will need to import significant amounts of green hydrogen and hydrogen derivatives to meet its projected hydrogen demand. Therefore, existing supply chains need to be restructured, and new ones must be built up. Besides reducing hydrogen supply costs, this pursuit raises the critical challenge of navigating risks associated with hydrogen imports by selecting reliable trading partners.

EWI Future Energy Score: A comparative tool

The study analyses the performance of potential hydrogen-exporting countries from an importer's perspective by relying on a large dataset with various variables capturing the situation in a country from 2017 to 2021. A PCA was used to compute EFES based on four sub-indicators: political, economic, social, and energy. Each of these four sub-indicators contributes equally to the overall EFES. The EFES allows a new, multifaceted perspective as countries performed differently in the various sub-indicators.

The role of EWI Future Energy Score in partner and project selection

The presented EFES plays a crucial role in facilitating the selection of hydrogen partners. By creating a country score, the EFES allows the comparison of potential hydrogen exporters with each other and can support political and business decision-makers. Thus, the EFES empowers companies and public authorities to identify promising hydrogen partners. In addition, this analysis aims to foster the debate on a holistic view of hydrogen exporters, expanding the mere techno-economic considerations.

Beyond the EFES: The hydrogen supply costs

Besides the EFES or its sub-indicators, the techno-economic potentials, including production potentials, production costs, and transport costs, are essential when choosing hydrogen projects. Several studies and tools assessing the techno-economic hydrogen potential of countries are already available (e.g., PtX Cost Tool (EWI, 2022)).

Limitations and further prospects

Despite valuable insights offered by the EFES, some data coverage and quality limitations must be acknowledged. Based on the specific timeframe of the data used, the EFES provides just a snapshot of a country's situation. As global and domestic affairs are subject to abrupt changes, no predictions about future developments can be made based on the EFES, as it is not intended as a forecasting instrument. Significant disruptions, such as the Russian war against Ukraine that began in early 2022, would be expected to become visible in the data for 2022 and 2023.

In addition, it has to be noted that this assessment has been conducted from an importer’s perspective with the target of mitigating risks to a secure hydrogen supply. For mutually beneficial collaboration and successful projects, the partner countries' interests need to be equally assessed and considered.

The EFES is adaptable and can be extended by stakeholders to align with their objectives. For instance, the score can be tailored to identify potential future energy exporters that ensure a high level of human rights or offer a good business environment. The four sub-indicators – political, economic, social, and energy – can be modified, complemented with additional sub-indicators, or calculated with different weights.

Data availability steered the analysis with implications on the results restricting the timespan, the thematic covering of risks, and the countries included in the analysis. Some countries, including the United States, Vietnam, South Korea, Luxembourg, and Slovenia, lack data in at least one of the four sub-indicators, which hinders calculating an EFES. When assessing a smaller number of countries, the data availability might increase, allowing us to consider more recent years and expand the thematic coverage.

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List of abbreviations

EAA	European Economic Area
EFES	EWI Future Energy Score
GESRI	Geopolitical Energy Supply Risk Index
IEA	International Energy Agency
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
KMO	Kaiser-Meyer-Olkin
OECD	Organisation for Economic Co-operation and Development
PC	Principal Component
PCA	Principal Component Analysis
REACCESS	Risk of Energy Availability: Common Corridors for Europe Supply Security
RES	Renewable Energy Sources
SMC	Squared Multiple Correlation
TEP	Total Energy Production
WACC	Weighted average cost of capital

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Appendix

A.1 Overview of chosen hydrogen partnerships with Germany

In the following, the official German hydrogen partner countries are briefly introduced, discussing domestic hydrogen activities as well as the main socio-economic parameters.

Canada

In August 2022, Germany and Canada signed the "Canada-Germany-Hydrogen-Alliance" with the aim of establishing a transatlantic hydrogen supply chain. The first Canadian hydrogen deliveries are expected to arrive in Germany as early as 2025. Canada aims to become the world's largest hydrogen exporter by 2050. The eastern part of the country, in particular, has enormous potential for the production of green hydrogen using renewable energies (Federal Ministry for Economic Affairs and Climate Action, 2023).

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): 0.2 (2018)
- Population: 38,929,902 (2022)
- GDP (current US$): 2.14 trillion (2022)
- GDP p.c. (current US$): 54,966 (2022)
- GDP growth (annual %): 3.4 (2022)
- Unemployment total (% of total labor force): 5.2 % (2022)
- 17.37 % of total energy production (TEP) from fossil fuels (mainly gas), 69.74 % from RES (mainly hydropower)
- Main economic sectors: Real estate, manufacturing, and mining

Source: World Bank Open Data (2023c), Investopedia (2023), Ritchie et al. (2022)

Chile

An energy partnership with Chile has been in place since 2019, which was expanded in 2021 to include a task force on green hydrogen. Within the framework of the task force, more than 50 hydrogen projects are planned or already being implemented. The aim of the partnership is to support Chile on its way to climate neutrality in 2050 (Federal Ministry for Economic Affairs and Climate Action, 2023).

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): 0.7 (2018)
- Population: 19,603,733 (2022)
- GDP (current US$): 301.03 billion (2022)
- GDP p.c. (current US$): 15,355.5 (2022)
- GDP growth (annual %): 2.4 (2022)
- Unemployment total (% of total labor force): 7.8 % (2022)
- 47.04 % of TEP from fossil fuels (mainly coal), 52.96 % from RES (mainly hydropower) (2022)
- Main economic sectors: Agriculture and mining

Source: Ritchie et al. (2022), World Bank Open Data (2023c), Ministerio de Relaciones Exteriores de Chile (2023)

Namibia

In March 2022, the German and Namibian governments signed the Joint Declaration of Intent on hydrogen cooperation. The aim of the partnership is the export of green hydrogen to Germany and the industrial transformation in Namibia. The two countries want to cooperate closely in the production, processing, application, and transport of green hydrogen and associated synthetic fuels (Federal Ministry for Economic Affairs and Climate Action, 2023)

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): 15.6 (2015)
- Population: 2,567,012 (2022)
- GDP (current US$): 12.61 billion (2022)
- GDP p.c. (current US$): 4,358.14 (2022)
- GDP growth (annual %): 4.6 (2022)
- Unemployment total (% of total labor force): 20.8 % (2022)
- 4.46 % of TEP from fossil fuels (mainly coal), 95.54 % from RES (mainly hydropower) (2021)
- Main economic sectors: Mining and manufacturing

Source: Ritchie et al. (2022), World Bank Open Data (2023c), World Bank (2023i)

Egypt

So far, Germany and Egypt have not entered a hydrogen partnership; instead, they plan to strengthen cooperation in the production of green hydrogen and the trade of LNG. In addition, political, economic, and scientific cooperation is to be intensified to enable a better exchange of knowledge. The aim is to implement various projects regarding the production, processing, use, and transport of green hydrogen. Basically, a sector for green hydrogen is to be established, and joint investment is to be promoted (Federal Ministry for Economic Affairs and Climate Action, 2023).

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): 1.5 (2019)
- Population: 110,990,103 (2022)
- GDP (current US$): 476.75 billion (2022)
- GDP p.c. (current US$): 4,585.33 (2022)
- GDP growth (annual %): 6.6 (2022)
- Unemployment total (% of total labor force): 7 % (2022)
- 88.78 % of TEP from fossil fuels (mainly gas), 11.22 % from RES (mainly hydropower) (2022)
- Main economic sectors: Textiles, food processing, tourism, and chemicals

Source: Ritchie et al. (2022), World Bank Open Data (2023c), globalEDGE (2023)

So far, Germany and Egypt have not entered a hydrogen partnership; instead, they plan to strengthen cooperation in the production of green hydrogen and the trade of LNG. In addition, political, economic, and scientific cooperation is to be intensified to enable a better exchange of knowledge. The aim is to implement various projects regarding the production, processing, use, and transport of green hydrogen. Basically, a sector for green hydrogen is to be established, and joint investment is to be promoted (Federal Ministry for Economic Affairs and Climate Action, 2023).

Morocco

Germany and Morocco have been engaged in an energy partnership since 2012, focusing on decarbonizing the power sector, supporting the private sector in the energy sector, and, since 2021, assisting Morocco in implementing its hydrogen strategy. The goal is to help Morocco realize their great potential for wind and solar energy as well as the production of green hydrogen. The integration of the two markets can enable a mutually beneficial and long-term energy supply. Geographical proximity and interconnections are advantageous for this (Federal Ministry for Economic Affairs and Climate Action, 2023).

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): 1.4 (2013)
- Population: 37,457,971 (2022)
- GDP (current US$): 134.18 billion (2022)
- GDP p.c. (current US$): 3,934.24 (2022)
- GDP growth (annual %): 1.1 (2022)
- Unemployment total (% of total labor force): 10.5 % (2022)
- 80.19 % of TEP from fossil fuels (mainly gas), 17.38 % from RES (mainly wind) (2022)
- Main economic sectors: Agriculture and manufacturing

Source: Ritchie et al. (2022), World Bank Open Data (2023c), Moody's Analytics (2023a)

Saudi Arabia

An energy dialogue between Germany and Saudi Arabia has been in place since 2019, which was expanded to include hydrogen cooperation in 2022. This cooperation is set out in a memorandum of understanding. The aim is to accelerate the market ramp-up of green hydrogen (Federal Ministry for Economic Affairs and Climate Action, 2023).

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): n.a.
- Population: 36,408,820 (2022)
- GDP (current US$): 1.1 trillion (2022)
- GDP p.c. (current US$): 30,436.3 (2022)
- GDP growth (annual %): 8.7 (2022)
- Unemployment total (% of total labor force): 5.6 % (2022)
- 99.79 % of TEP from fossil fuels (mainly gas), 0.21 % from RES (mainly solar) (2022)
- Main economic sectors: Petroleum

Source: Ritchie et al. (2022), World Bank Open Data (2023c), Moody's Analytics (2023b)

Australia

In 2017, Australia and Germany entered into an energy partnership with a focus on energy efficiency. In June 2021, this partnership was expanded by a joint declaration of intent on strategic cooperation in the hydrogen sector, namely "Australia-Germany-Hydrogen-Alliance". Planned initiatives include the establishment of a German-Australian Hydrogen Innovation and Technology Incubator (HyGATE), the establishment of a German-Australian Hydrogen Hub, and investigations into opportunities for establishing supply chains for hydrogen and its derivatives from Australia to Germany.

Country facts

- Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population): 0.5 (2018)
- Population: 25,978,935 (2022)
- GDP (current US$): 1.68 trillion (2022)
- GDP p.c. (current US$): 64,491.4 (2022)
- GDP growth (annual %): 3.6 (2022)
- Unemployment total (% of total labor force): 3.7 % (2022)
- 67.7 % of TEP from fossil fuels (mainly coal), 32.30 % from RES (mainly solar) (2022)
- Main economic sectors: Manufacturing, construction, and mining

Source: Ritchie et al. (2022), World Bank Open Data (2023c), Remplan economy (2023)

A.2 Database

Table 13: Overview of data sources

Category	Variable	Unit	Source
Economic	GDP	Current USD	World Bank (2023)
	GDP based on PPP	Constant 2017 USD	World Bank (2023)
	GDP per capita	Current USD per capita	World Bank (2023)
	GDP per capita based on PPP	Constant 2017 USD per capita	World Bank (2023)
	GDP growth	Annual change (%)	World Bank (2023)
	GDP per capita growth	Annual change (%)	World Bank (2023)
	Inflation	Annual change (%)	World Bank (2023)
	Unemployment	Share of total labor force	World Bank (2023)
	Government Debt based on LCU	Current LCU	World Bank (2023)
	Government Debt based on GDP	Share of GDP	World Bank (2023)
	Economic Freedom Index	Score: 0-100 (100 = most freedom)	Heritage (2023)
	Economy Status Index	Score: 0-10 (10 = highest status)	Atlas-bti (2022)
	Public finance flows for renewable energy supply	Billion 2020 USD	IRENA (2020)
	Balance of payments, current account	Current USD	IMF (2023)
	Balance of payments, capital account	Current USD	IMF (2023)
	Balance of payments, financial account	Current USD	IMF (2023)
	Exchange Rate	National currency per current USD	IMF (2023)
	Interest Rate	Percent per annum	IMF (2023)
	Financial Development Index	Score: 0-1 (1 = most developed)	IMF (2023)
	Country Risk Classification Index	Scores: 0-7 (7 = lowest risk)	OECD (2023)
	Ease of Doing Business Rank	Ranking: 1-183 (183 = most difficult)	World Bank (2021)
	Global Competitiveness Index	Scores: 1-7 (7 = highest competition)	World Economic Forum (2019)
	Logistic Performance Index	Score: 1-5 (5 = best performance)	World Bank (2023)

Category	Variable	Unit	Source
Economic	Foreign direct investments, inflows	Currency USD	World Bank (2023)
	Foreign direct investments, outflows	Currency USD	World Bank (2023)
	Exports	Currency USD	World Bank (2023)
	Imports	Currency USD	World Bank (2023)
	Export growth	Annual growth (%)	World Bank (2023)
	Import growth	Annual growth (%)	World Bank (2023)
	Export Quality Index	Theil indices	IMF (2017)
	Export Diversification Index	Theil indices	IMF (2017)
	World Port Index, total	Number of ports	NGA (2020)
	World Port Index, medium size	Number of medium-sized ports	NGA (2020)
	World Port Index, large size	Number of large-sized ports	NGA (2020)
Political	World Power Index	Score: 0-1 (1 = most power)	Morales Ruvalcaba (2022)
	Global Peace Index	Score: 1-5 (5 = least peaceful)	Vision of Humanity (2023a)
	Global Terrorism Index	Score: 0-10 (10 = highest impact of terrorism)	Vision of Humanity (2023b)
	Rule of Law Index	Score: -2.5-2.5 (2.5 = best score)	World Bank (2023)
	Government Effectiveness Index	Score: -2.5-2.5 (2.5 = most effective)	World Bank (2023)
	Political Stability Index	Score: -2.5-2.5 (2.5 = most stable)	World Bank (2023)
	Regulatory Quality Index	Score: -2.5-2.5 (2.5 = highest quality)	World Bank (2023)
	Control of Corruption Index	Score: -2.5-2.5 (2.5 = most control)	World Bank (2023)
	Corruption Perception Index	Score: 0-100 (100 = least corrupt)	Transparency International (2022)
	Fragile State Index	Score: 0-120 (120 = most fragile)	The Fund for Peace (2023)
	Voice & Accountability Index	Score: -2.5-2.5 (2.5 = most participation)	World Bank (2023)
	Democracy Status Index	Score: 0-10 (10 = most democratic)	Atlas-bti (2022)
	Governance Performance Index	Score: 0-10 (10 = best performance)	Atlas-bti (2022)
	Government Difficulty Index	Score: 0-10 (10 = most difficult)	Atlas-bti (2022)

Category	Variable	Unit	Source
Political	Government Index	Score: 0-10 (10 = most developed)	Atlas-bti (2022)
	Geopolitical Risk Index	Score: 0-5 (5 = highest risk)	Caldara and Iacoviello (2022)
	Political Rights Rating	Score: 0-10 (10 = least rights)	Freedom House (2023)
	Civil Liberties Rating	Score: 0-10 (10 = least liberties)	Freedom House (2023)
	Combined Polity Score	Score: -10-10 (10 = most democratic)	Systemic Peace (2018)
Social	Population	Total	World Bank (2023)
	Population growth	Annual change (%)	World Bank (2023)
	Population density	Population per sqm	World Bank (2023)
	Ethnic Fractionalization Index	Score: 0-1 (1 = highest fractionalization)	Drazanova (2019)
	Human Rights Index	Score: 0-1 (1 = most rights)	V-Dem (2023)
	Youth unemployment	Share of total labor force between ages 15-24	World Bank (2023)
	Poverty gap at 2.15 USD a day	2017 PPP (%)	World Bank (2023)
	Poverty gap at 3.65 USD a day	2018 PPP (%)	World Bank (2023)
	Poverty gap at 6.85 USD a day	2019 PPP (%)	World Bank (2023)
	Multidimensional Poverty Index	Score: 0-100 (100 = extreme poverty)	UN (2022a)
	Human Development Index	Score: 0-1 (1 = most developed)	UN (2021)
	World Happiness Index	Score: 0-10 (10 = most happy)	WHR (2022)
	Homicides	Incidents per 100,000 people	World Bank (2023)
	Access to electricity	Share of total population	World Bank (2023)
	Water stress level	Freshwater withdrawal as a proportion of available freshwater resources	World Bank (2023)
	Safe water consumption	Share of total population	World Bank (2023)
	Gini Index	Score: 0-1 (1 = most concentrated)	World Bank (2023)
	School enrollment, primary education	Share of enrolled population of total population in corresponding age class	World Bank (2023)
	School enrollment, secondary education	Share of enrolled population of total population in corresponding age class	World Bank (2023)

	School enrollment, tertiary education	Share of enrolled population of total population in corresponding age class	World Bank (2023)

Category	Variable	Unit	Source
Social	Account at a financial institution or mobile money service	Share of population with account of total population	World Bank (2023)
	Account at a financial institution	Share of population with account of total population	World Bank (2023)
	Climate Risk Index	Score: 0-15 (15 = lowest risk)	Germanwatch (2023)
	Multi Vulnerability Index	Score: 0-100 (100 = most vulnerable)	UN (2023)
	Gender Development Index	Score: 0-1.1 (1.1 = most developed)	IMF (2023)
	Gender Inequality Index	Score: 0-1.1 (1.1 = most equal)	IMF (2023)
	Gender employment gap, all sectors	Ratio of women compared to men	IEA (2022a)
	Gender employment gap, energy sector	Ratio of women compared to men	IEA (2022a)
	Gender employment gap, non-energy sectors	Ratio of women compared to men	IEA (2022a)
	Net migration rate	Per 1.000 people	UN (2022b)
	Happy Planet Index	Score: 0-100 (100 = happiest)	Wellbeing Economy Alliance (2021)
Energy	CO_2-emissions per capita	Metric tons per capita	World Bank (2023)
	Energy production	Thousand tons of oil equivalent	IEA (2023c)
	Energy use	Kg of oil equivalent per capita	World Bank (2023)
	Energy intensity	MJ per constant 2017 GDP (PPP)	IEA (2023c)
	GDP per energy use	Constant 2017 USD (PPP) per kg of oil equivalent	World Bank (2023)
	GDP per energy use based on PPP	USD (PPP) per kg of oil equivalent	World Bank (2023)
	Fossil fuel energy consumption	Share of total final energy consumption	World Bank (2023)
	Renewable energy consumption	Share of total final energy consumption	World Bank (2023)
	Renewable energy consumption based on IEA	Share of total final energy consumption	IEA (2023b)

Category	Variable	Unit	Source
	Renewable energy supply of total energy supply	Share of total energy supply	IEA (2023c)
	Petroleum and other consumption	Thousand tons of oil equivalent	EIA (2022)
Category	Variable	Unit	Source
Energy	Electricity from fossil fuels	Share of total energy supply	IEA (2023c)
	Electricity from renewable energy sources	Share of total energy supply	IEA (2023c)
	Natural gas production	Thousand tons of oil equivalent	IEA (2023b)
	Natural gas exports	Thousand tons of oil equivalent	IEA (2023b)
	Natural gas exports of total energy exports	Share of total energy exports	IEA (2023c)
	Natural gas imports	Thousand tons of oil equivalent	IEA (2023b)
	Natural gas reserves	Billion cubic feet	EIA (2022)
	Natural gas reserves per production	Share of total natural gas production	EIA (2022)
	Natural gas self-sufficiency	Ratio of natural gas production to total primary energy supply	IEA (2023c)
	Oil exports	Thousand tons of oil equivalent	IEA (2023b)
	Oil imports	Thousand tons of oil equivalent	IEA (2023b)
	Oil exports to total energy exports	Share of total energy exports	IEA (2023c)
	Oil and gas exports	Thousand tons of oil equivalent	IEA (2023b)
	Oil and gas exports to total energy exports	Thousand tons of oil equivalent	IEA (2023c)
	Oil reserves	Million barrels	EIA (2022)
	Oil self-sufficiency	Ratio of oil production to total primary energy supply	IEA (2023c)
	Total energy self-sufficiency	Ratio of production to total primary energy supply	IEA (2023c)
	Energy imports to final energy consumption	Ratio of energy imports to final energy consumption	IEA (2023c)
	Level of carbon tax	USD	Dolphin and Xiahou (2022)
	Carbon price based on ETS	USD	Dolphin and Xiahou (2022)

Category	Variable	Unit	Source
	Hydrogen production capacities	Million standard cubic feet per day	H_2Tools (2017)
	R & D for energy efficiency	Million constant 2022 USD (PPP)	IEA (2023a)
	R & D for fossil fuels	Million constant 2022 USD (PPP)	IEA (2023a)
Energy	R & D for hydrogen & fuel cells	Million constant 2022 USD (PPP)	IEA (2023a)
	R & D for nuclear energy	Million constant 2022 USD (PPP)	IEA (2023a)
	R & D for renewable energies	Million constant 2022 USD (PPP)	IEA (2023a)
	R & D for other cross-cutting technologies	Million constant 2022 USD (PPP)	IEA (2023a)
	R & D for other power & storage technologies	Million constant 2022 USD (PPP)	IEA (2023a)
	R & D for energy technologies	Million constant 2022 USD (PPP)	IEA (2023a)
	Methane emissions	Kilotonnes	IEA (2022d)
	Methane abatement	Kilotonnes	IEA (2022d)
	Fossil fuel subsidies	Nominal Million USD	IEA (2022c)
	Hydrogen patents	number of patents for H_2 and Fuel Cells	IEA (2022b)

A.3 Formal description of the concept of the Principal Component Analysis

This section is mainly concerned with providing a more formal description of the concept of Principal Component Analysis (PCA). The PCA aims to decrease the number of variables by providing a dataset that contains numerous interconnected variables while preserving a significant portion of the data's variation. This is accomplished by transforming the data into a new set of variables called Principal Components (PCs), which are uncorrelated. These components are ordered to ensure the initial few components retain the majority of the variation found in all the original variables.

The PCA can be explained from a different perspective, which goes beyond what is discussed in section (3.2). For the population version of PCA rather than the sample version, assume there is vector Y composed of p random variables, and interest lies in the structure of the correlations among the p variables. If p is small or the structure is very simple, then the solution is simple by looking at the p variances and all of $1/2\,p(p-1)$ correlations. However, since this is not the case, alternatively, one can look for a few $(\ll p)$ derived variables that retain the majority of information provided by the variances and correlations of the original dataset. The PCA starts with searching for a linear function $\alpha_1' Y$ of the elements of Y that gives maximum variance and α_1 is a vector of p constants (α_{11} , α_{12} , …, α_{1p}), where

$$\alpha_1' Y = \alpha_{11} y_1 + \alpha_{12} y_2 + \cdots + \alpha_{1p} y_p = \sum_{j=1}^{p} \alpha_{1j} y_j$$

Then, search for a linear function $\alpha_2' Y$, where it provides maximum variance while being uncorrelated with $\alpha_1' Y$. This is done until reaching the kth-derived variable ($\alpha_k' Y$) known as the kth PC, where p PCs can be found. However, the aim is to find q PCs, such that $q \ll p$ while retaining most of the variation of the original dataset. The α_k is the eigenvector, and λ_k is the eigenvalue. The λ_k corresponds to the variance of z_k, where $z_k = \alpha_k' Y$ (Joliffe, 2002; Joliffe, 2022). Then, component scores are calculated by projecting the original data onto the selected PCs, where the standardized data is multiplied by the eigenvectors. Component scores are then combined to form the sub-indicators and the EFES.

A.4 Sub-indicators and EWI Future Energy Score

Political

Table 14: Political sub-indicator

Country	2017	2018	2019	2020	2021
Afghanistan	52	55	54	54	52
Albania	45	44	44	44	44
Algeria	42	42	41	40	40
Angola	24	27	28	28	29
Argentina	58	59	58	56	55
Australia	75	76	74	76	74
Austria	72	72	70	76	74
Azerbaijan	29	28	28	27	28
Bahamas	0	0	0	0	0
Bahrain	43	41	40	38	38
Bangladesh	49	46	42	42	42
Barbados	0	0	0	0	0
Belarus	25	26	25	26	25
Belgium	79	78	76	75	70
Benin	46	46	52	48	51
Bhutan	43	42	42	43	46
Bolivia	40	40	40	39	39
Bosnia and Herzegovina	45	43	41	37	37
Botswana	50	50	50	50	50
Brazil	53	52	55	53	50
Bulgaria	51	50	50	49	49
Burundi	36	32	31	30	33
Cambodia	25	26	26	24	24
Cameroon	45	47	47	47	47
Canada	80	80	78	77	73
Caribbean	0	0	0	0	0
Central African Republic	34	34	32	29	22
Chad	36	35	37	38	38
Chile	74	76	77	77	79
China	43	41	38	35	34
Colombia	65	66	68	67	67
Congo	0	0	0	0	0
Congo Democratic Republic	0	0	0	0	0
Costa Rica	58	59	59	58	58
Cote d'Ivoire	49	48	46	49	47
Croatia	53	53	53	53	53
Cuba	23	22	23	23	23
Cyprus	65	64	63	64	62
Czech Republic	64	63	62	61	61
Denmark	74	74	73	71	71
Djibouti	29	28	26	24	25
Dominican Republic	43	43	43	43	45
Ecuador	39	51	52	50	50
Egypt	51	49	48	47	46
El Salvador	46	46	45	44	43
Equatorial Guinea	13	13	13	13	14

Country	2017	2018	2019	2020	2021
Eritrea	12	13	13	14	14
Estonia	65	65	65	66	65
Eswatini	0	0	0	0	0
Ethiopia	40	39	41	41	41
Fiji	0	0	0	0	0
Finland	78	77	76	74	71
France	80	81	79	77	77
Gabon	31	29	27	27	28
Gambia	28	34	33	35	36
Georgia	56	55	54	53	49
Germany	81	81	81	81	78
Ghana	50	50	50	49	50
Gibraltar	0	0	0	0	0
Greece	64	64	67	69	68
Greenland	0	0	0	0	0
Guatemala	37	37	37	37	37
Guinea	29	29	31	28	29
Haiti	24	24	25	25	26
Honduras	37	37	36	35	33
Hong Kong	0	0	0	0	0
Hungary	53	51	48	48	45
Iceland	64	64	64	65	64
India	70	71	70	70	70
Indonesia	57	60	59	60	60
Iran	40	41	41	40	39
Iraq	56	56	55	54	54
Ireland	69	68	69	70	66
Israel	79	76	74	73	76
Italy	66	68	70	68	68
Jamaica	50	50	52	52	53
Japan	65	64	70	69	66
Jordan	47	47	47	46	44
Kazakhstan	38	36	36	36	30
Kenya	57	56	56	55	56
Kosovo	0	0	0	0	0
Kuwait	46	45	43	36	33
Laos	29	27	25	24	19
Latvia	58	57	58	59	58
Lebanon	53	49	49	46	45
Lesotho	41	41	42	41	40
Liberia	36	37	36	34	36
Libya	39	39	38	36	35
Liechtenstein	0	0	0	0	0
Lithuania	61	61	66	64	60
Luxembourg	0	0	0	0	0
Macedonia	0	0	0	0	0
Madagascar	45	43	42	43	36
Malawi	39	39	38	39	40
Malaysia	50	52	53	52	50
Maldives	0	0	0	0	0
Mali	57	58	59	55	54
Malta	0	0	0	0	0
Mauritania	28	32	32	32	31
Mexico	56	55	55	54	50

Country	2017	2018	2019	2020	2021
Monaco	0	0	0	0	0
Mongolia	48	48	49	48	47
Montenegro	47	46	45	45	47
Morocco	36	41	41	40	38
Mozambique	47	51	53	53	52
Myanmar	42	43	47	45	46
Namibia	50	50	49	50	50
Nepal	49	51	51	51	50
Netherlands	76	76	74	74	75
New Zealand	69	69	83	81	79
Nicaragua	37	35	29	29	26
Niger	54	54	55	57	59
Nigeria	60	60	59	56	56
North Korea	13	12	13	14	14
Norway	74	72	76	74	71
Oman	33	34	34	35	35
Pakistan	61	60	57	55	57
Panama	50	51	53	53	49
Paraguay	51	51	51	49	46
Peru	59	58	58	57	57
Philippines	65	65	65	63	62
Poland	60	59	56	55	52
Polynesia	0	0	0	0	0
Portugal	61	61	61	61	60
Puerto Rico	0	0	0	0	0
Qatar	35	36	36	37	38
Romania	51	57	55	53	53
Russia	44	44	43	43	42
Rwanda	36	32	37	36	36
Saudi Arabia	42	41	41	40	39
Senegal	48	56	53	50	49
Serbia	46	46	44	42	42
Seychelles	0	0	0	0	0
Singapore	53	54	53	54	51
Slovakia	58	57	56	56	59
Slovenia	59	59	60	61	59
Somalia	0	0	0	0	0
South Africa	54	59	59	57	55
South Korea	59	59	59	59	58
South Sudan	24	22	20	17	20
Spain	74	73	73	70	65
Sri Lanka	44	49	58	55	55
Sudan	27	24	23	23	24
Suriname	0	0	0	0	0
Swaziland	0	0	0	0	0
Sweden	79	78	77	75	73
Switzerland	73	75	73	76	76
Syria	39	40	39	40	41
Taiwan	0	0	0	0	0
Tanzania	45	41	43	44	43
Thailand	52	51	49	52	48
Togo	33	34	32	33	36
Tunisia	64	62	61	60	59
Turkey	62	56	56	54	51

Country	2017	2018	2019	2020	2021
Uganda	36	36	33	30	40
Ukraine	60	59	55	55	50
United Arab Emirates	42	39	38	38	37
United Kingdom	85	84	81	80	79
United States	86	82	81	79	77
Uruguay	65	64	63	67	66
Uzbekistan	19	20	21	22	24
Venezuela	27	35	30	29	28
Vietnam	26	30	30	30	28
Yemen	41	39	38	36	35
Zambia	35	35	35	34	34
Zimbabwe	24	23	26	26	25

Note: Lighter writing indicates that there was no data available to compute the political sub-indicator for that country.

Source: Own calculations

Economic

Table 15: Economic sub-indicator

Country	2017	2018	2019	2020	2021
Afghanistan	0	0	0	0	0
Albania	45	44	44	40	49
Algeria	38	38	38	36	41
Angola	38	35	34	34	37
Argentina	43	41	40	38	45
Australia	55	56	56	55	57
Austria	53	53	53	50	55
Azerbaijan	0	0	0	0	0
Bahamas	46	47	47	36	50
Bahrain	48	47	0	0	0
Bangladesh	43	45	44	41	44
Barbados	0	0	0	0	0
Belarus	44	46	43	42	46
Belgium	53	52	53	50	56
Benin	41	40	40	37	46
Bhutan	0	0	0	0	0
Bolivia	41	40	39	35	42
Bosnia and Herzegovina	45	45	45	42	48
Botswana	46	48	46	43	49
Brazil	46	45	45	43	47
Bulgaria	47	47	47	45	49
Burundi	38	37	0	0	0
Cambodia	43	45	44	40	44
Cameroon	38	39	40	36	40
Canada	56	56	56	52	58
Caribbean	0	0	0	0	0
Central African Republic	0	0	0	0	0
Chad	0	0	0	0	0
Chile	47	48	47	45	51
China	0	0	0	0	0
Colombia	44	44	44	39	47
Congo	0	0	0	0	0
Congo Democratic Republic	0	0	35	37	0
Costa Rica	46	46	45	43	48
Cote d'Ivoire	44	43	43	40	43
Croatia	48	47	48	43	53
Cuba	0	0	0	0	0
Cyprus	51	49	51	47	50
Czech Republic	0	0	0	0	0
Denmark	54	55	55	53	57
Djibouti	0	0	0	0	0
Dominican Republic	44	45	44	39	49
Ecuador	40	39	39	37	41
Egypt	49	44	41	40	41
El Salvador	44	44	44	40	48
Equatorial Guinea	0	0	0	0	0
Eritrea	0	0	0	0	0
Estonia	49	49	49	47	52
Eswatini	0	0	0	0	0
Ethiopia	0	0	0	0	0

Country	2017	2018	2019	2020	2021
Fiji	0	0	0	0	0
Finland	53	52	52	51	54
France	55	56	56	50	58
Gabon	0	0	0	0	0
Gambia	39	41	36	35	39
Georgia	47	47	47	41	50
Germany	69	71	68	65	72
Ghana	44	42	42	34	51
Gibraltar	0	0	0	0	0
Greece	47	47	47	43	50
Greenland	0	0	0	0	0
Guatemala	43	43	43	41	46
Guinea	42	38	38	37	47
Haiti	0	0	0	0	0
Honduras	43	42	42	38	47
Hong Kong	0	0	0	0	0
Hungary	48	48	50	48	50
Iceland	52	52	50	46	53
India	47	47	45	44	51
Indonesia	46	46	45	43	49
Iran	0	0	0	0	0
Iraq	0	0	0	0	0
Ireland	57	59	57	57	65
Israel	51	52	52	50	55
Italy	55	55	54	50	58
Jamaica	45	46	46	39	48
Japan	63	63	64	59	64
Jordan	45	44	45	41	48
Kazakhstan	44	45	44	42	44
Kenya	40	40	40	38	42
Kosovo	0	0	0	0	0
Kuwait	44	45	42	42	0
Laos	0	0	0	0	0
Latvia	48	48	47	45	48
Lebanon	44	43	41	33	41
Lesotho	0	0	0	0	0
Liberia	0	0	0	0	0
Libya	0	0	0	0	0
Liechtenstein	0	0	0	0	0
Lithuania	49	48	49	47	51
Luxembourg	57	57	58	59	61
Macedonia	0	0	0	0	0
Madagascar	43	40	40	36	41
Malawi	0	0	0	0	0
Malaysia	51	50	50	48	52
Maldives	41	41	41	28	54
Mali	42	41	43	40	42
Malta	50	49	49	46	51
Mauritania	42	42	42	39	41
Mexico	47	48	47	45	50
Monaco	0	0	0	0	0
Mongolia	45	47	45	40	44
Montenegro	0	0	0	0	0
Morocco	45	44	44	41	45

Country	2017	2018	2019	2020	2021
Mozambique	35	41	36	33	38
Myanmar	0	0	0	0	0
Namibia	43	45	42	39	44
Nepal	44	44	42	38	40
Netherlands	62	54	57	50	58
New Zealand	52	52	51	48	53
Nicaragua	42	39	40	40	44
Niger	41	40	40	39	41
Nigeria	40	42	41	33	40
North Korea	0	0	0	0	0
Norway	54	55	53	51	57
Oman	43	43	43	41	45
Pakistan	43	43	43	41	43
Panama	47	47	46	39	51
Paraguay	44	43	42	40	44
Peru	46	46	45	41	50
Philippines	47	47	46	41	46
Poland	50	50	50	48	52
Polynesia	0	0	0	0	0
Portugal	50	50	50	45	52
Puerto Rico	0	0	0	0	0
Qatar	48	50	49	48	51
Romania	48	48	47	44	48
Russia	48	50	48	46	52
Rwanda	45	44	44	40	43
Saudi Arabia	44	46	44	41	47
Senegal	41	41	0	0	0
Serbia	0	0	0	0	0
Seychelles	45	44	44	38	47
Singapore	62	62	61	59	65
Slovakia	47	47	47	45	48
Slovenia	48	48	48	45	51
Somalia	0	0	0	0	0
South Africa	47	47	46	43	49
South Korea	58	58	56	56	60
South Sudan	0	0	0	0	0
Spain	54	54	53	48	56
Sri Lanka	45	44	42	39	44
Sudan	38	0	0	0	0
Suriname	0	0	0	0	0
Swaziland	0	0	0	0	0
Sweden	55	55	55	52	58
Switzerland	60	60	60	55	63
Syria	0	0	0	0	0
Taiwan	0	0	0	0	0
Tanzania	0	0	0	0	0
Thailand	51	51	50	46	51
Togo	40	40	40	40	41
Tunisia	43	43	42	38	44
Turkey	49	48	48	46	51
Uganda	41	41	40	39	40
Ukraine	42	42	43	41	43
United Arab Emirates	0	0	0	0	0
United Kingdom	58	55	56	51	60

Country	**2017**	2018	2019	2020	2021
United States	65	60	59	52	59
Uruguay	47	46	46	43	49
Uzbekistan	43	45	44	40	45
Venezuela	0	0	0	0	0
Vietnam	46	46	46	46	47
Yemen	0	0	0	0	0
Zambia	0	0	0	0	0
Zimbabwe	0	0	0	0	0

Note: Lighter writing indicates that there was no data available to compute the economic sub-indicator for that country.

Source: Own calculations

Social

Table 16: Social sub-indicator

Country	2017	2018	2019	2020	2021
Afghanistan	62	62	62	62	55
Albania	85	85	86	86	87
Algeria	71	71	71	71	70
Angola	57	58	59	59	59
Argentina	83	84	83	84	84
Australia	85	85	85	86	89
Austria	87	87	87	87	87
Azerbaijan	72	71	72	71	72
Bahamas	0	0	0	0	0
Bahrain	62	66	71	75	75
Bangladesh	67	67	67	68	69
Barbados	84	84	84	84	84
Belarus	80	81	81	73	72
Belgium	88	88	88	88	88
Benin	64	63	63	62	62
Bhutan	75	76	77	77	76
Bolivia	77	77	75	75	77
Bosnia and Herzegovina	87	86	86	86	87
Botswana	73	73	74	75	74
Brazil	81	80	78	78	77
Bulgaria	86	86	86	85	86
Burundi	43	42	41	43	44
Cambodia	64	63	65	64	63
Cameroon	60	61	61	61	62
Canada	86	85	86	86	88
Caribbean	0	0	0	0	0
Central African Republic	0	0	0	0	0
Chad	45	45	45	45	44
Chile	83	82	82	82	84
China	0	0	0	0	0
Colombia	78	76	75	75	76
Congo	54	54	54	54	55
Congo Democratic Republic	0	0	0	0	0
Costa Rica	84	83	84	84	85
Cote d'Ivoire	65	66	66	65	65
Croatia	89	88	87	87	95
Cuba	73	73	73	72	71
Cyprus	85	85	85	85	85
Czech Republic	87	87	87	87	92
Denmark	88	88	89	88	88
Djibouti	58	59	59	59	60
Dominican Republic	80	80	80	81	81
Ecuador	79	79	79	80	80
Egypt	62	62	63	63	63
El Salvador	79	79	79	77	76
Equatorial Guinea	53	54	54	55	56
Eritrea	0	0	0	0	0
Estonia	88	87	87	88	88
Eswatini	0	0	0	0	0
Ethiopia	51	55	57	57	56

Country	2017	2018	2019	2020	2021
Fiji	80	80	80	79	78
Finland	89	89	89	89	89
France	87	87	87	87	87
Gabon	0	0	0	0	0
Gambia	64	65	66	66	66
Georgia	85	85	86	85	86
Germany	88	89	89	89	89
Ghana	73	73	74	74	74
Gibraltar	0	0	0	0	0
Greece	88	88	88	88	88
Greenland	0	0	0	0	0
Guatemala	73	73	73	73	73
Guinea	55	57	55	53	53
Haiti	0	0	0	0	0
Honduras	71	73	73	74	73
Hong Kong	0	0	0	0	0
Hungary	86	85	85	85	86
Iceland	84	83	84	86	86
India	71	72	71	71	72
Indonesia	77	77	77	76	77
Iran	68	68	68	69	69
Iraq	66	67	65	64	66
Ireland	87	86	86	87	87
Israel	80	80	81	81	82
Italy	88	88	91	88	89
Jamaica	82	83	83	83	82
Japan	89	89	89	89	89
Jordan	0	0	0	0	0
Kazakhstan	73	73	73	74	74
Kenya	0	0	0	0	0
Kosovo	0	0	0	0	0
Kuwait	35	28	33	44	46
Laos	0	0	0	0	0
Latvia	72	89	90	90	90
Lebanon	0	0	0	0	0
Lesotho	63	66	65	67	66
Liberia	63	62	62	63	62
Libya	56	55	56	56	56
Liechtenstein	0	0	0	0	0
Lithuania	91	90	88	87	87
Luxembourg	83	84	84	84	85
Macedonia	0	0	0	0	0
Madagascar	59	61	60	60	60
Malawi	58	59	59	60	60
Malaysia	0	0	0	0	0
Maldives	65	66	73	75	77
Mali	57	59	60	59	59
Malta	0	0	0	0	0
Mauritania	0	0	0	0	0
Mexico	78	78	78	78	78
Monaco	0	0	0	0	0
Mongolia	77	78	78	78	79
Montenegro	0	0	0	0	0
Morocco	73	73	73	73	73

Country	2017	2018	2019	2020	2021
Mozambique	54	55	55	55	55
Myanmar	0	0	0	0	0
Namibia	70	70	71	71	70
Nepal	0	0	0	0	0
Netherlands	88	88	87	87	88
New Zealand	84	85	86	84	88
Nicaragua	70	64	63	63	62
Niger	54	53	54	54	54
Nigeria	0	0	0	0	0
North Korea	0	0	0	0	0
Norway	88	89	88	88	88
Oman	67	72	76	78	76
Pakistan	62	62	62	61	61
Panama	80	80	80	81	81
Paraguay	79	79	79	78	78
Peru	80	79	79	80	80
Philippines	72	71	71	71	70
Poland	85	86	86	86	86
Polynesia	0	0	0	0	0
Portugal	88	88	88	87	86
Puerto Rico	0	0	0	0	0
Qatar	61	68	69	77	78
Romania	87	87	87	87	87
Russia	77	77	77	77	77
Rwanda	0	0	0	0	0
Saudi Arabia	56	55	56	60	61
Senegal	66	66	67	67	67
Serbia	84	84	84	84	85
Seychelles	0	0	0	0	0
Singapore	0	0	0	0	0
Slovakia	87	86	86	86	87
Slovenia	0	0	0	0	0
Somalia	0	0	0	0	0
South Africa	78	77	76	76	76
South Korea	0	0	0	0	0
South Sudan	0	0	0	0	0
Spain	87	87	87	87	88
Sri Lanka	78	80	80	78	76
Sudan	0	0	0	0	0
Suriname	80	80	80	80	80
Swaziland	0	0	0	0	0
Sweden	86	87	87	88	88
Switzerland	88	88	88	88	88
Syria	72	68	63	66	69
Taiwan	0	0	0	0	0
Tanzania	58	58	59	59	60
Thailand	72	73	75	73	74
Togo	61	61	62	64	63
Tunisia	79	78	78	78	78
Turkey	69	71	72	72	72
Uganda	52	53	53	53	53
Ukraine	81	81	82	83	83
United Arab Emirates	58	58	59	59	58
United Kingdom	87	87	87	87	87

Country	2017	2018	2019	2020	2021
United States	0	0	0	0	0
Uruguay	86	86	86	86	86
Uzbekistan	0	0	0	0	0
Venezuela	66	71	72	68	66
Vietnam	0	0	0	0	0
Yemen	0	0	0	0	0
Zambia	58	60	60	59	60
Zimbabwe	58	58	58	59	58

Note: Lighter writing indicates that there was no data available to compute the social sub-indicator for that country.

Source: Own calculations

Energy

Table 17: Energy sub-indicator

Country	2017	2018	2019	2020	2021
Afghanistan	0	0	0	0	0
Albania	35	36	35	35	35
Algeria	33	33	32	32	33
Angola	37	37	37	38	38
Argentina	28	29	29	29	29
Australia	36	37	39	40	40
Austria	33	33	33	34	33
Azerbaijan	28	28	29	29	29
Bahamas	0	0	0	0	0
Bahrain	27	27	27	27	27
Bangladesh	27	27	27	27	27
Barbados	0	0	0	0	0
Belarus	26	26	25	25	26
Belgium	28	28	28	28	28
Benin	29	29	30	29	29
Bhutan	0	0	0	0	0
Bolivia	29	30	30	31	30
Bosnia and Herzegovina	28	29	30	30	29
Botswana	27	26	27	27	27
Brazil	36	37	37	37	37
Bulgaria	27	27	28	27	28
Burundi	0	0	0	0	0
Cambodia	33	32	33	32	32
Cameroon	36	36	36	36	36
Canada	47	47	46	46	47
Caribbean	0	0	0	0	0
Central African Republic	0	0	0	0	0
Chad	0	0	0	0	0
Chile	30	31	31	31	31
China	41	41	42	42	42
Colombia	34	35	34	34	34
Congo	0	0	0	0	0
Congo Democratic Republic	0	0	0	0	0
Costa Rica	36	36	36	37	37
Cote d'Ivoire	31	32	33	33	33
Croatia	32	32	33	32	32
Cuba	27	27	27	27	27
Cyprus	26	26	26	27	27
Czech Republic	27	27	27	27	27
Denmark	33	34	34	35	35
Djibouti	0	0	0	0	0
Dominican Republic	27	27	27	27	27
Ecuador	32	33	33	33	33
Egypt	27	28	29	29	29
El Salvador	33	34	34	34	35
Equatorial Guinea	0	0	0	0	0
Eritrea	32	31	31	32	32
Estonia	27	28	28	29	31
Eswatini	0	0	0	0	0
Ethiopia	40	40	40	40	40

Country	2017	2018	2019	2020	2021
Fiji	0	0	0	0	0
Finland	31	32	32	32	32
France	27	27	27	27	27
Gabon	37	37	38	37	37
Gambia	0	0	0	0	0
Georgia	33	33	33	32	32
Germany	28	26	27	27	28
Ghana	33	32	32	32	32
Gibraltar	25	25	25	25	25
Greece	29	29	29	29	30
Greenland	0	0	0	0	0
Guatemala	35	35	35	35	35
Guinea	0	0	0	0	0
Haiti	32	32	33	33	32
Honduras	32	33	33	33	33
Hong Kong	0	0	0	0	0
Hungary	27	27	27	27	27
Iceland	40	40	40	40	40
India	33	33	33	33	33
Indonesia	34	34	33	33	33
Iran	37	37	37	37	37
Iraq	30	30	30	31	30
Ireland	28	28	28	29	29
Israel	26	26	26	26	27
Italy	28	28	28	28	29
Jamaica	26	27	27	27	27
Japan	23	23	23	23	24
Jordan	26	26	26	27	27
Kazakhstan	31	31	30	30	30
Kenya	38	37	38	38	39
Kosovo	27	27	27	27	27
Kuwait	30	30	30	30	30
Laos	35	35	35	36	36
Latvia	33	34	32	32	33
Lebanon	25	25	25	26	26
Lesotho	0	0	0	0	0
Liberia	0	0	0	0	0
Libya	28	28	28	27	28
Liechtenstein	0	0	0	0	0
Lithuania	31	32	32	32	31
Luxembourg	30	31	31	32	32
Macedonia	0	0	0	0	0
Madagascar	35	35	35	35	35
Malawi	0	0	0	0	0
Malaysia	31	31	31	31	31
Maldives	0	0	0	0	0
Mali	0	0	0	0	0
Malta	27	26	26	26	26
Mauritania	0	0	0	0	0
Mexico	27	27	27	27	27
Monaco	0	0	0	0	0
Mongolia	0	0	0	0	0
Montenegro	31	31	32	32	31
Morocco	27	27	27	27	27

Country	2017	2018	2019	2020	2021
Mozambique	38	38	38	38	38
Myanmar	0	0	0	0	0
Namibia	34	34	34	35	34
Nepal	38	38	38	38	38
Netherlands	34	34	33	32	34
New Zealand	35	35	35	35	34
Nicaragua	33	34	34	34	35
Niger	31	31	31	32	32
Nigeria	38	38	38	38	37
North Korea	32	33	33	32	33
Norway	51	50	50	50	50
Oman	28	30	41	30	36
Pakistan	31	30	30	31	31
Panama	32	32	32	31	32
Paraguay	42	41	41	40	40
Peru	32	33	33	33	33
Philippines	30	30	30	30	30
Poland	27	27	27	27	27
Polynesia	0	0	0	0	0
Portugal	31	30	31	31	32
Puerto Rico	0	0	0	0	0
Qatar	43	44	44	43	43
Romania	30	30	30	30	30
Russia	69	71	73	70	72
Rwanda	36	36	35	36	37
Saudi Arabia	38	39	38	37	38
Senegal	28	28	28	29	29
Serbia	28	28	28	28	28
Seychelles	0	0	0	0	0
Singapore	29	28	28	28	28
Slovakia	28	28	28	28	28
Slovenia	29	28	29	29	29
Somalia	0	0	0	0	0
South Africa	26	26	27	27	27
South Korea	0	0	0	0	0
South Sudan	0	0	0	30	0
Spain	29	29	29	29	30
Sri Lanka	31	31	32	31	31
Sudan	35	35	35	35	35
Suriname	29	30	30	30	30
Swaziland	0	0	0	0	0
Sweden	33	33	33	34	35
Switzerland	31	31	31	31	32
Syria	26	26	26	26	26
Taiwan	0	0	0	0	0
Tanzania	34	34	34	34	35
Thailand	29	29	29	29	29
Togo	35	34	34	34	33
Tunisia	26	26	26	26	26
Turkey	27	27	27	28	28
Uganda	40	40	39	40	40
Ukraine	26	26	26	26	27
United Arab Emirates	32	31	32	32	32
United Kingdom	29	29	30	30	30

Country	2017	2018	2019	2020	2021
United States	62	66	71	71	75
Uruguay	37	37	37	37	37
Uzbekistan	28	28	28	27	27
Venezuela	38	38	38	38	40
Vietnam	30	31	30	29	30
Yemen	26	26	27	27	27
Zambia	39	38	38	38	38
Zimbabwe	34	35	35	35	35

Note: Lighter writing indicates that there was no data available to compute the energy sub-indicator for that country.

Source: Own calculations

EWI Future Energy Score

Table 18: EWI Future Energy Score

Country	2017	2018	2019	2020	2021
Afghanistan	0	0	0	0	0
Albania	52	53	52	51	54
Algeria	46	46	46	45	46
Angola	39	39	40	40	40
Argentina	53	53	53	51	53
Australia	63	63	64	64	65
Austria	61	61	61	62	62
Azerbaijan	0	0	0	0	0
Bahamas	0	0	0	0	0
Bahrain	45	45	0	0	0
Bangladesh	47	46	45	44	45
Barbados	0	0	0	0	0
Belarus	44	45	44	42	42
Belgium	62	62	61	60	60
Benin	45	45	46	44	47
Bhutan	0	0	0	0	0
Bolivia	47	47	46	45	47
Bosnia and Herzegovina	51	51	50	49	50
Botswana	49	50	49	49	50
Brazil	54	53	54	53	53
Bulgaria	53	52	53	52	53
Burundi	0	0	0	0	0
Cambodia	41	42	42	40	41
Cameroon	45	46	46	45	46
Canada	67	67	66	65	66
Caribbean	0	0	0	0	0
Central African Republic	0	0	0	0	0
Chad	0	0	0	0	0
Chile	59	59	59	59	61
China	0	0	0	0	0
Colombia	55	55	55	54	56
Congo	0	0	0	0	0
Congo Democratic Republic	0	0	0	0	0
Costa Rica	56	56	56	56	57
Cote d'Ivoire	47	47	47	47	47
Croatia	55	55	55	54	58
Cuba	0	0	0	0	0
Cyprus	57	56	56	56	56
Czech Republic	0	0	0	0	0
Denmark	62	63	62	62	63
Djibouti	0	0	0	0	0
Dominican Republic	48	49	49	48	50
Ecuador	47	51	50	50	51
Egypt	47	46	45	45	45
El Salvador	50	51	51	49	50
Equatorial Guinea	0	0	0	0	0
Eritrea	0	0	0	0	0
Estonia	57	57	57	57	59
Eswatini	0	0	0	0	0
Ethiopia	0	0	0	0	0

Country	2017	2018	2019	2020	2021
Fiji	0	0	0	0	0
Finland	63	62	62	61	61
France	62	63	63	60	62
Gabon	0	0	0	0	0
Gambia	0	0	0	0	0
Georgia	55	55	55	53	54
Germany	67	67	66	66	67
Ghana	50	49	49	47	52
Gibraltar	0	0	0	0	0
Greece	57	57	58	57	59
Greenland	0	0	0	0	0
Guatemala	47	47	47	46	48
Guinea	0	0	0	0	0
Haiti	0	0	0	0	0
Honduras	46	46	46	45	47
Hong Kong	0	0	0	0	0
Hungary	53	53	53	52	52
Iceland	60	60	60	59	61
India	55	56	55	55	57
Indonesia	53	54	54	53	55
Iran	0	0	0	0	0
Iraq	0	0	0	0	0
Ireland	60	60	60	61	62
Israel	59	59	58	58	60
Italy	59	60	61	59	61
Jamaica	51	51	52	50	52
Japan	60	60	61	60	61
Jordan	0	0	0	0	0
Kazakhstan	46	46	46	45	44
Kenya	0	0	0	0	0
Kosovo	0	0	0	0	0
Kuwait	39	37	37	38	0
Laos	0	0	0	0	0
Latvia	53	57	56	57	57
Lebanon	0	0	0	0	0
Lesotho	0	0	0	0	0
Liberia	0	0	0	0	0
Libya	0	0	0	0	0
Liechtenstein	0	0	0	0	0
Lithuania	58	58	59	58	57
Luxembourg	0	0	0	0	0
Macedonia	0	0	0	0	0
Madagascar	45	45	44	43	43
Malawi	0	0	0	0	0
Malaysia	0	0	0	0	0
Maldives	0	0	0	0	0
Mali	0	0	0	0	0
Malta	0	0	0	0	0
Mauritania	0	0	0	0	0
Mexico	52	52	52	51	51
Monaco	0	0	0	0	0
Mongolia	0	0	0	0	0
Montenegro	0	0	0	0	0
Morocco	45	46	46	45	46

Country	2017	2018	2019	2020	2021
Mozambique	44	46	45	45	46
Myanmar	0	0	0	0	0
Namibia	49	50	49	49	50
Nepal	0	0	0	0	0
Netherlands	65	63	63	61	63
New Zealand	60	60	63	62	64
Nicaragua	46	43	41	41	42
Niger	45	45	45	45	46
Nigeria	0	0	0	0	0
North Korea	0	0	0	0	0
Norway	67	66	67	66	67
Oman	43	45	48	46	48
Pakistan	49	49	48	47	48
Panama	52	52	53	51	53
Paraguay	54	54	53	52	52
Peru	54	54	54	52	55
Philippines	54	53	53	51	52
Poland	56	55	55	54	54
Polynesia	0	0	0	0	0
Portugal	58	57	57	56	57
Puerto Rico	0	0	0	0	0
Qatar	47	49	49	51	52
Romania	54	55	55	54	55
Russia	60	60	60	59	61
Rwanda	0	0	0	0	0
Saudi Arabia	45	45	45	44	46
Senegal	46	48	0	0	0
Serbia	0	0	0	0	0
Seychelles	0	0	0	0	0
Singapore	0	0	0	0	0
Slovakia	55	55	54	54	56
Slovenia	0	0	0	0	0
Somalia	0	0	0	0	0
South Africa	51	52	52	51	52
South Korea	0	0	0	0	0
South Sudan	0	0	0	0	0
Spain	61	61	60	58	60
Sri Lanka	49	51	53	51	51
Sudan	0	0	0	0	0
Suriname	0	0	0	0	0
Swaziland	0	0	0	0	0
Sweden	64	63	63	62	63
Switzerland	63	64	63	63	65
Syria	0	0	0	0	0
Taiwan	0	0	0	0	0
Tanzania	0	0	0	0	0
Thailand	51	51	51	50	50
Togo	42	42	42	43	43
Tunisia	53	52	52	51	52
Turkey	52	51	51	50	50
Uganda	42	42	41	40	43
Ukraine	52	52	52	51	51
United Arab Emirates	0	0	0	0	0
United Kingdom	64	64	63	62	64

Country	2017	2018	2019	2020	2021
United States	0	0	0	0	0
Uruguay	59	58	58	58	59
Uzbekistan	0	0	0	0	0
Venezuela	0	0	0	0	0
Vietnam	0	0	0	0	0
Yemen	0	0	0	0	0
Zambia	0	0	0	0	0
Zimbabwe	0	0	0	0	0

Note: Lighter writing indicates that there was at least in one sub-indicator no data available to compute the respective score. However, to build the EFES, a score for all sub-indicators is needed.

Source: Own calculations