KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

cce INDEX
Circular Carbon Economy Index
مؤشر الاقتصاد الدائري للكربون

The Circular Carbon Economy Index 2022 – Results

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About KAPSARC

KAPSARC is an advisory think tank within global energy economics and sustainability providing advisory services to entities and authorities in the Saudi energy sector to advance Saudi Arabia's energy sector and inform global policies through evidence-based advice and applied research.

This publication is also available in Arabic.

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Executive Summary and Key Messages

The circular carbon economy (CCE) concept provides a holistic, flexible and pragmatic framework for countries to plan their energy and economic transitions to lower carbon dioxide and greenhouse gas emission levels and, ultimately, net-zero emissions. The CCE Index measures countries' progress in and potential for reaching CCEs. It is a composite indicator comprising 43 individual, quantitative variables or indicators. The datasets underlying each indicator are harmonized across countries and derived from robust and reputable sources. When aggregated together, the index and its sub-components provide tools for policymakers and other climate change and energy policy stakeholders to explore and compare how well countries are performing on these two dimensions of the CCE. The index is intended as a support tool for policymaking, and as such can be used in many ways that go beyond simple comparisons of country scores and ranks.

The CCE Index has been developed by a dedicated team at KAPSARC and was first launched in 2021. This discussion paper presents the results of the second, 2022 edition of the index. The 2022 CCE Index includes 64 countries: the largest economies from each region and major oil and gas producing countries globally. In addition to the 2022 CCE Index scores, this edition also presents revised scores for the 2021 CCE Index. Going forward, scores for previous years' editions will always be recalculated to account for data and possible indicator framework updates and, by doing so, to ensure their comparability over time.

The following high-level messages stand out from the 2022 CCE Index:

- In 2022, five European countries, Norway, the Netherlands, Germany, the United Kingdom and Switzerland, top the CCE Index. At the bottom are five Sub-Saharan African countries. The gap between these top five and bottom five performers is notable (46 points), which indicates that countries toward the end of the list in particular will be in need of significant assistance to be able to successfully transition to CCEs. Countries around the median score are a more heterogeneous group, from various regions and income groups, namely Ecuador, the Philippines, the Russian Federation, Qatar and Thailand.

- In the area of CCE Performance, a large number of countries are not yet deploying some of the most important technologies necessary for achieving full carbon circularity: countries toward the bottom of the ranking generally have lower levels of modern renewables or nuclear energy in their energy mixes, and they also lack project pipelines for newer carbon circularity technologies, namely hydrogen and carbon capture, utilization and storage. Energy efficiency is a key component in lowering emissions, but alone it is insufficient. Electrification only supports CCEs if the source of power generation is clean. Transitioning away from coal and oil in the power sector is beneficial, but will, in the longer term, require full decarbonization; and natural sinks are a major contributor to carbon circularity, but are only a part of the overall solution and always incorporate the risk of non-permanence.

- In the area of CCE Enablers, industrialized countries top the ranking. At the bottom is a geographically more diverse group of developing countries. Similar to the CCE Performance sub-index, almost two-thirds of countries score below the average CCE Enablers score, and there is a significant gap between the top and bottom performers. Common to all five dimensions of this sub-index, which measure areas such as policy, technology, finance, business environments and energy system resilience, is that the top-five performers are always high-income countries. The bottom-five countries in the rankings, however, are more diverse, with a mix of low-, middle- and even high-income countries across the dimensions. The gap between the top and bottom performers is the widest in the 'finance and investment' (83 points) and 'system resilience' (80 points) dimensions and narrowest in the 'business environment' (44 points) dimension.

- On the Oil Producers Lens score, which is an add-on score given to the major hydrocarbon producers included in the index, the top three countries, Norway, the Netherlands and the United Kingdom, also rank high on the total CCE Index. The three lowest-scoring countries, Algeria, Iraq and Uzbekistan, are placed in the lowest quadrant of the total CCE Index. By and large, oil and gas producers score higher on the Oil Producers Lens than the total CCE Index. Saudi Arabia, the Netherlands and Qatar score the highest in the five oil producer-specific performance indicators, which measure industrial carbon circularity performance.

- Compared with the 2021 CCE Index (which has been recalculated to accommodate for the larger country group and various indicator framework updates), 57 countries improved their total CCE Index scores in 2022, while seven saw a deterioration in their scores. The average increase of countries' scores between 2021 and 2022 was 1.36, reflecting the fact that energy transitions are a gradual and long-term process. Sustained attention over the coming years and decades to accelerating progress toward CCEs and net-zero emissions will be fundamental.

Introduction

This KAPSARC Discussion Paper presents the results of the 2022 Circular Carbon Economy (CCE) Index, which provides quantitative metrics for measuring and comparing how countries are performing on the CCE at present and how well they are equipped to accelerate progress toward CCEs and net-zero emissions going forward.

This is the second edition of the CCE Index, which was originally launched in 2021. A detailed description of the methodology is presented in KAPSARC Methodology Paper, "The Circular Carbon Economy Index 2021 – Methodology" (Luomi, Yilmaz, and Alshehri 2021a). This edition contains three important updates. First, the number of countries included in the index has been increased from 30 to 64, extending coverage to more than 90% of the global gross domestic product (GDP) and greenhouse gas (GHG) emissions (World Bank 2022; WRI et al. 2022). Second, the indicator framework has been updated to ensure optimal data coverage across the larger group of countries. Third, from the 2022 edition onward, index scores will be recalculated for any past editions to ensure comparability over time. A brief explanation of these updates is provided below, and more details are available in Appendix 1.

The full 2022 CCE Index results are available on the CCE Index web portal, https://cceindex.kapsarc.org/, which also contains updated results for 2021. The web portal further includes two interactive tools that allow advanced users to simulate results and rankings for alternative scenarios by toggling either indicator weights or country-level indicator values.

CCE Concept and the CCE Index

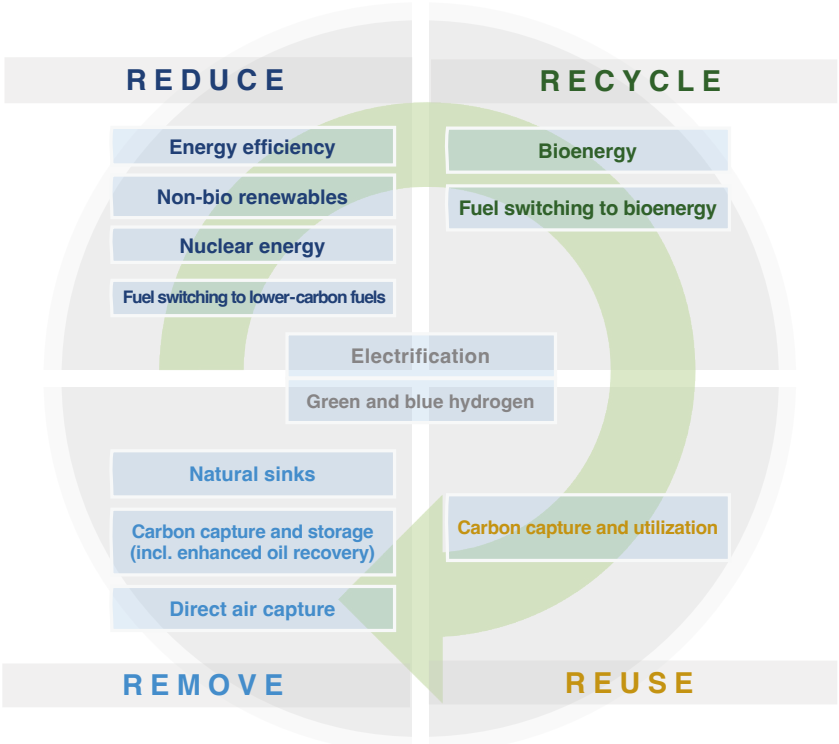
The CCE concept provides a holistic, flexible and pragmatic framework for countries to plan their energy and economic transitions to lower carbon dioxide (CO2) and GHG emission levels and, ultimately, net-zero emissions. Previous publications, including KAPSARC (2020), Luomi et al. (2021), Luomi, Yilmaz, and Alshehri (2021a) and Alshehri et al. (2022), provide more detailed discussions on the CCE concept and how the CCE Index seeks to measure it in a country comparison context.

In short, the CCE provides a conceptual frame for examining net-zero emission transitions through the lens of four 'Rs' relating to the management of carbon and related emissions flows: reduce, reuse, recycle, and remove. The concept draws attention to the need for technology-neutral approaches to delivering the needed transitions, playing to each country's strengths, prioritizing cost-effectiveness, and ensuring other policy drives, including economic and social sustainability, are also accounted for when pursuing carbon circularity.

Figure 1 presents a graphic illustration of the main technology options and mitigation approaches available in the CCE 'toolkit'.[1] These 'CCE activities' form the basis for the CCE Performance sub-index, which accounts for half of the CCE Index score (with the other sub-index focused on CCE Enablers).

The CCE Index measures countries' progress in and potential for reaching CCEs. It is a composite indicator comprising 43 individual, quantitative indicators. The datasets underlying each indicator are harmonized across countries and derived from robust and reputable sources. When aggregated, the index and its sub-components provide tools for policymakers and other climate change and energy policy stakeholders to explore and compare how well countries are performing on these two dimensions of the CCE.

Figure 1. The circular carbon economy.



Source: Luomi, Yilmaz, and Alshehri (2021a, 2021b).

The index is intended as a support tool for policymaking, and as such can be used in many ways that go beyond simple comparisons of country scores and ranks. Questions, such as why a country received a particular score in a particular area or an indicator, can open the doors to discussions about indicator appropriateness or the quality of the data for a country, which are valuable as they can encourage countries to generate better or more policy-relevant data. Ideally, however, closer examinations of countries' scores would help spark action in a particular area where a country is performing below its peers, or encourage further efforts where a country is either on par with others or leading.

An important point to highlight is that the CCE Index or its main sub-components do not seek to provide a measure of the level of ambition of countries' climate change policies, such as targets communicated in nationally determined contributions under the Paris Agreement. While the CCE Enabler indicators, which measure countries' CCE transition potential, incorporate policy-related indicators (such as whether a country has set a net-zero emission target), even these are intended as measures of the overall enabling environment rather than comparative indicators of policy ambition.

CCE Index Country Coverage in the 2022 Edition

The 2022 edition includes 64 countries: the largest economies from each region and major oil and gas producing countries.[2] In its inaugural edition in 2021, the index covered 30 major economies and oil producers. From 2022 onward, the current, extended country coverage is expected to remain stable. The group now includes a broad selection of countries from different regions and various levels of socioeconomic development, and covers more than 90% the world's GHG emissions and GDP (WRI et al., 2022; World Bank 2022).

Figure 2. Countries Included in the 2022 CCE Index.[3]

East Asia and the Pacific	Europe and Central Asia	Latin America and the Caribbean	Middle East and North Africa	North America	Sub-Saharan Africa
Australia	**Azerbaijan**	***Argentina***	*Algeria*	***Canada***	***Angola***
China	*France*	***Brazil***	Bahrain	***United States***	Cameroon
Indonesia	*Germany*	Chile	**Egypt**	**South Asia**	Côte D'Ivoire
Japan	*Italy*	Colombia	***Iran***	Bangladesh	Ethiopia
Malaysia	***Kazakhstan***	Costa Rica	***Iraq***	***India***	Ghana
Philippines	**Netherlands**	Dominican Republic	Jordan	Pakistan	Kenya
Republic of Korea	***Norway***	Ecuador	***Kuwait***	Sri Lanka	***Nigeria***
Singapore	Poland	Guatemala	Lebanon		*South Africa*
Thailand	***Russian Federation***	***Mexico***	Morocco		Tanzania
Viet Nam	Spain	Peru	***Oman***		Uganda
	Switzerland		***Qatar***		
	Türkiye		***Saudi Arabia***		
	United Kingdom		Tunisia		
	Uzbekistan		***United Arab Emirates***		

Key: Countries in *italics* were included in the 2021 CCE Index. Countries in **bold** also receive an Oil Producers Lens score.

Source: Authors' construction.

2022 CCE Index Framework

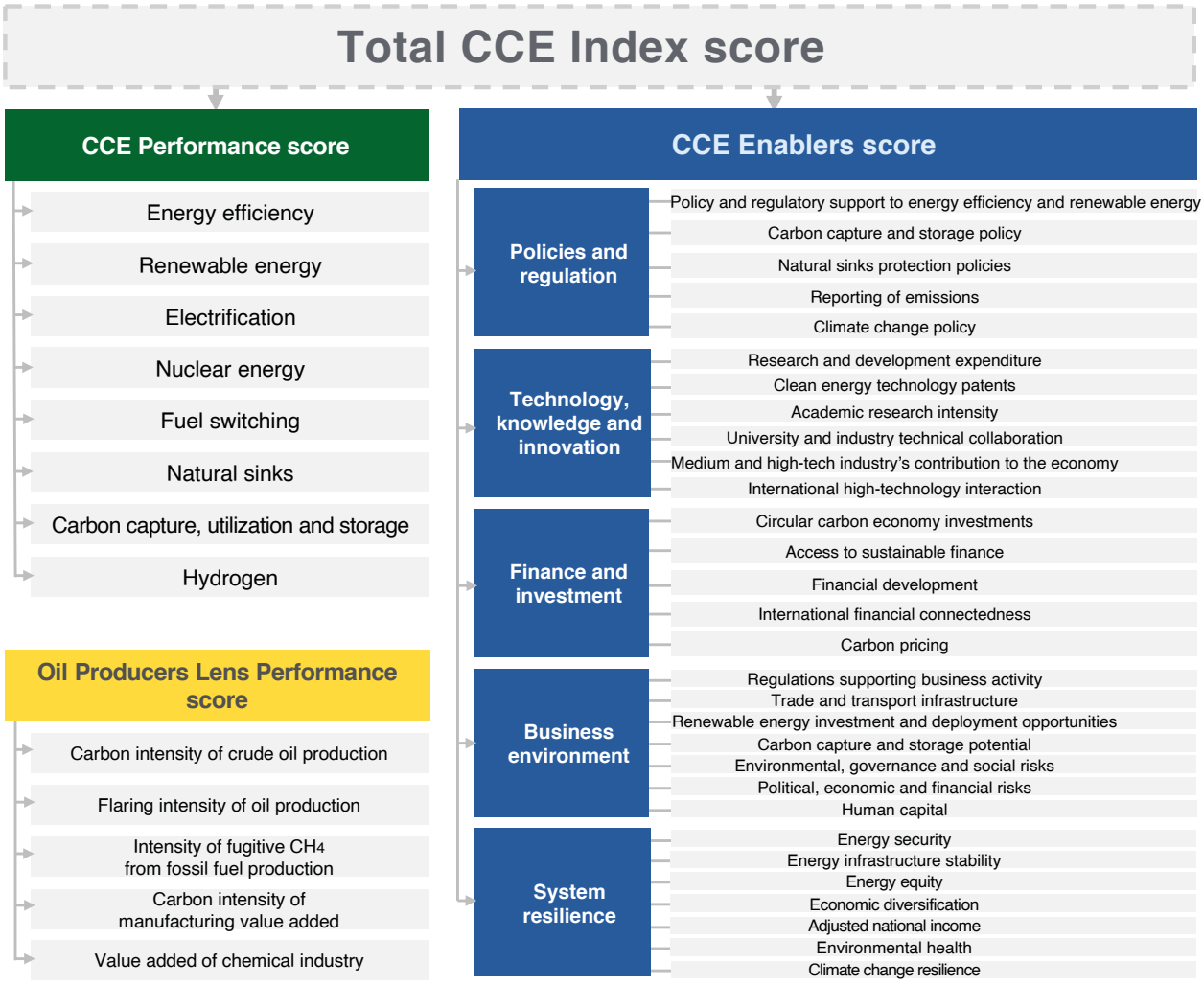
The CCE Index consists of two sub-indices. The CCE Performance sub-index gauges countries' performance across eight main CCE technologies and activities. The CCE Enablers sub-index measures countries' CCE transition potential through 30 indicators divided into five key areas: policies and regulation; technology, knowledge and innovation; finance and investment; business environment; and system resilience.

In total, the 2022 edition of the CCE Index contains 43 quantitative indicators. Each country receives a score on a scale of 0–100 for each indicator. Separate scores, similarly on a scale of 0–100, are first calculated for the sub-indices, which are then aggregated to form the total country score. In total, the CCE Index therefore consists of three aggregate

scores: the CCE Performance score, the CCE Enablers score, and the total CCE Index score. The scores should be interpreted as an indication of how close countries are to ideal performance, either compared with their top-ranking peers or a technical maximum. The detailed aggregation logic for the index is presented in Appendix 1, Figure A.1.

In addition, the major oil and gas producing countries included in the index receive a separate, additional score, called the Oil Producers Lens score. This score is generated by first calculating an aggregate score for five performance indicators (Oil Producers Lens Performance score) and then aggregating this with the total CCE Index score. The Oil Producers Lens indicators and scores allow for further comparisons among this group of countries that face a particular set of industry-related CCE transition challenges and opportunities. Figure 3 presents the complete 2022 CCE Index indicator framework.

Figure 3. 2022 CCE Index indicator framework.



Source: Authors' construction.

The 2022 edition introduces a number of changes to the indicator framework, which are discussed in more detail in Appendix 1. The main changes relate to reorganising two dimensions under CCE Enablers (business environment and system resilience) to improve conceptual consistency, and omitting the Oil Producers Lens Enablers dimension due to insufficient data availability and the discontinuation of datasets.

As a new feature, from 2022 onward, each CCE Index edition will also generate scores for the previous years in which the index has been published. In 2022, this means that the index will generate new scores for both 2022 and 2021. Going forward, the scores will be recalculated with each edition to ensure comparability across years in light of any changes or backward adjustments made by the original data sources to the underlying datasets. This also allows the index to be updated with new indicators or better datasets as they become available, ensuring it remains timely and relevant. While this means that countries' scores and ranks will see some changes in future updates of the index, the latest available edition of the index will always provide data that is up to date and comparable over time.

2022 CCE Index Results

This section presents and analyzes the results of the 2022 CCE Index. It first presents the total CCE Index scores, followed by the scores for its sub-indices and dimensions, as well as those for the Oil Producers Lens. The high-level 2022 CCE Index scores are presented in Appendix 1. The scores and rankings, full underlying datasets used in the index, and a 'codebook' containing detailed information about each indicator are available via the CCE Index web portal: https://cceindex.kapsarc.org

Total CCE Index

In 2022, five European countries, Norway, the Netherlands, Germany, the United Kingdom and Switzerland, top the CCE Index with total scores between 62 and 70 (Figure 4). At the bottom are five Sub-Saharan African countries, Uganda, Ethiopia, Nigeria, Tanzania and Cameroon, scoring between 15 and 22. The gap between these top five and bottom five performers is a notable 46 points. Countries around the median score (34) are a more heterogeneous group, from various regions and income groups, namely Ecuador, the Philippines, the Russian Federation, Qatar and Thailand.

The total CCE Index score is the average of countries' CCE Performance and CCE Enablers scores, which means that countries that achieve high scores on both generally rank the highest on this metric. The five highest-ranking countries in 2022 also rank in the top seven in both the CCE Performance and CCE Enablers sub-indices. Similarly, the countries at the bottom receive low scores in both sub-indices. Many countries receive higher scores from the Enablers sub-index, and therefore its contribution to the total score is, on average, higher (59%) than the Performance sub-index (41%). A number of countries diverge significantly from these averages: Angola, Iraq and Cameroon have much higher CCE Performance scores than their CCE Enablers scores, which could be interpreted as indicating that their progress going forward may be limited without a stronger focus on enabling environments. All three also fall in the bottom tertile of the ranking. On the other extreme are countries in the opposite situation, with significantly higher CCE Enabler scores compared with their CCE Performance scores. These include Uganda, which is at the bottom of the ranking, and Singapore, which ranks fifteenth in the total CCE Index.

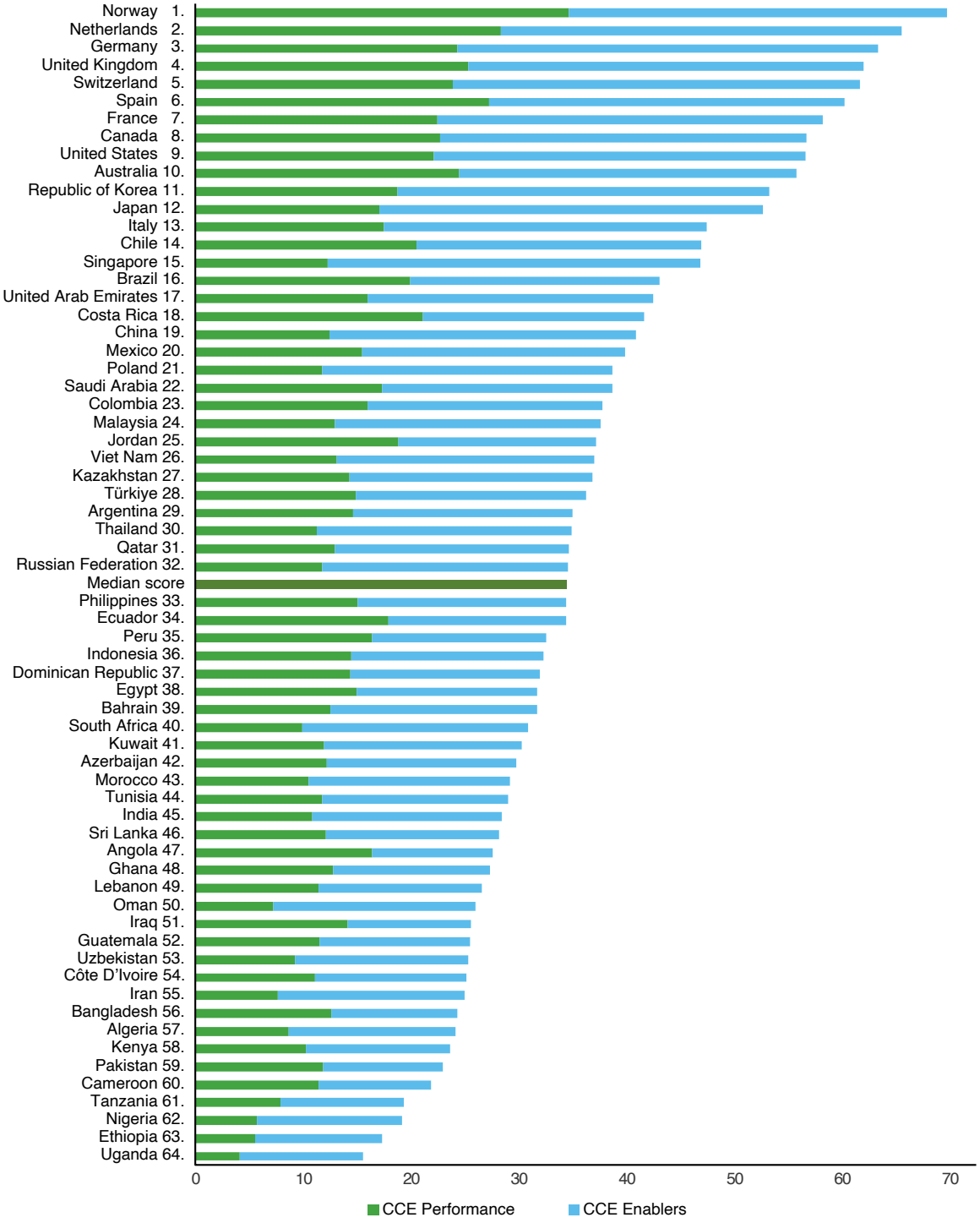
The following sections decompose the CCE Index further, highlighting top and bottom performers and key features of each sub-index and dimension. A similar decomposition approach (which is outside the scope of this paper) can be applied to individual countries to allow for a more granular understanding of what underlies each country's scores.

CCE Performance

The CCE Performance score indicates both the depth and breadth of a country's engagement with eight principal CCE technologies and activities currently available at commercial scale. In other words, it rewards countries that score well on not only one but various activities, which can vary from one country to the other. This also reflects the ethos of the CCE concept of utilizing all available approaches while building on each country's strengths.

At the top of the CCE Performance sub-index in 2022 are Norway, the Netherlands, Spain, the United Kingdom and Australia; all high-income industrialized countries (Figure 5). Norway stands out with a significantly higher score (69) than the other high-ranking countries (49-57). At the bottom is a more diverse group of countries: Uganda, Ethiopia, Nigeria, Oman and Iran. These countries generally receive extremely low scores on most indicators, except energy efficiency, fuel switching and natural sinks – all activities that do not involve the deployment of clean energy technologies.

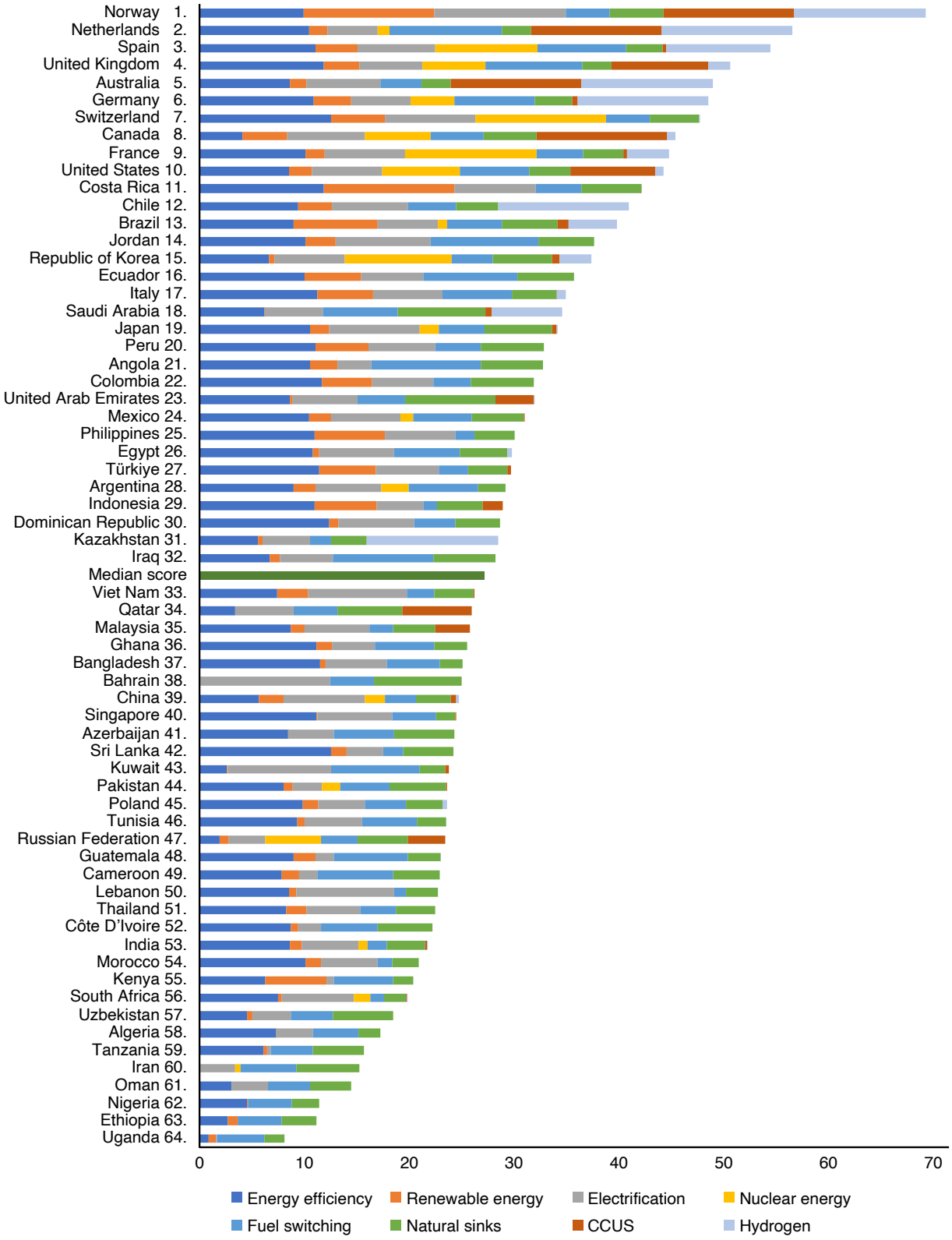
Figure 4. 2022 total CCE Index scores.



Source: Authors' construction.

Note: The length of the bar indicates the total CCE Index score. Different colors display the contribution of each sub-index to the total.

Figure 5. 2022 CCE Performance scores.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

With a few exceptions, countries toward the bottom of the ranking generally have lower levels of modern renewables[4] or nuclear energy in their energy mixes, and they also lack project pipelines for newer carbon circularity technologies, namely hydrogen and carbon capture, utilization and storage (CCUS). Reflecting this, the largest share of countries' CCE Performance scores, on average, comes from energy efficiency, followed by electrification, fuel switching and natural sinks. A further observation is that approximately 60% of the 64 countries measured by the index receive a score lower than the average score (30), meaning that high performance scores are concentrated among a smaller group of countries.

A key message from the 2022 CCE Performance sub-index, therefore, is that a large number of countries are not yet deploying some of the most important technologies necessary for achieving full carbon circularity. Energy efficiency is a key component in lowering emissions, but alone it is insufficient. Electrification only supports CCEs if the source of power generation is clean. Transitioning away from coal and oil in the power sector is beneficial, but it will, in the longer term, require full decarbonization; and natural sinks are a major contributor to carbon circularity, but are only a part of the overall solution and always incorporate the risk of non-permanence due to forest fires or competition from agricultural policies, for example.

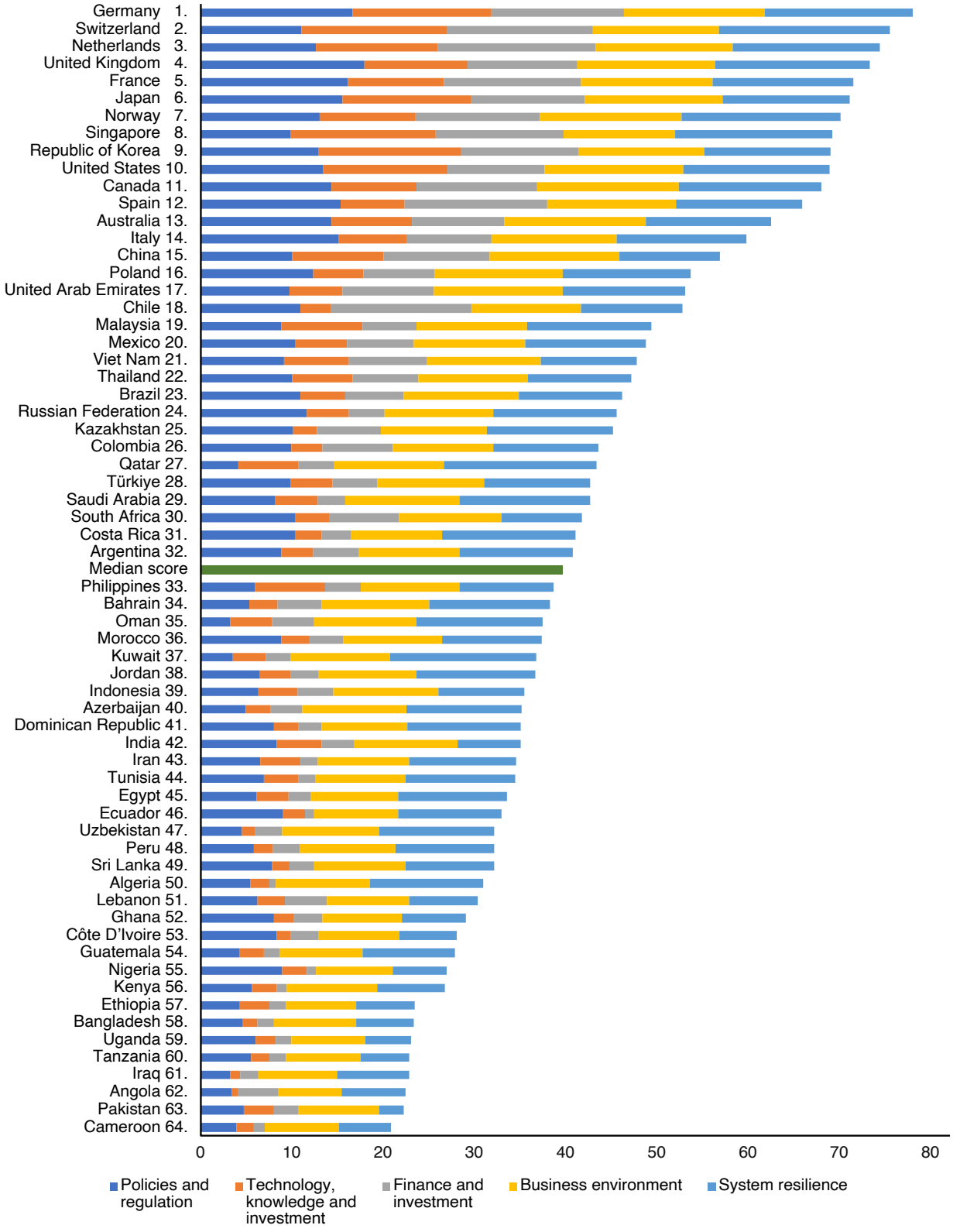
CCE Enablers

The CCE Enablers score gauges countries' potential and preparedness to transition toward CCEs and net-zero emission economies in five areas. In 2022, five European countries top the CCE Enablers sub-index: Germany, Switzerland, the Netherlands, the United Kingdom and France, with scores between 72 and 78 (Figure 6). At the bottom is a geographically more diverse group of developing countries, Cameroon, Pakistan, Angola, Iraq and Tanzania, which score between 21 and 23. As in the 2022 CCE Performance sub-index, approximately 60% of countries score below the average CCE Enablers score (44), and there is a significant gap between the top and bottom performers. These aggregate results reveal similar findings to those of the total CCE Index and the Performance sub-index, namely that developing countries will need significant support to accelerate their CCE transitions.

The following pages present a more detailed view of the five dimensions of the CCE Enablers sub-index, which comprises 30 indicators.

Policies and regulation: The five indicators under this dimension gauge government support for CCE transitions through various technology or activity-specific enabling policies (energy efficiency, renewable energy, carbon capture and storage [CCS] and natural sinks), the frequency of their GHG emissions inventory disclosures, and the strength of their commitment to reaching net-zero emissions. A similar pattern of top-ranking, industrialized countries and low-ranking developing countries of various income levels (except low income) is similarly apparent in this dimension as in the overall Enablers sub-index, as is a disproportionately large gap between top- and bottom-scoring countries, with the top performer, the United Kingdom, scoring 74 points higher than the lowest performer, Oman (Figure 7).

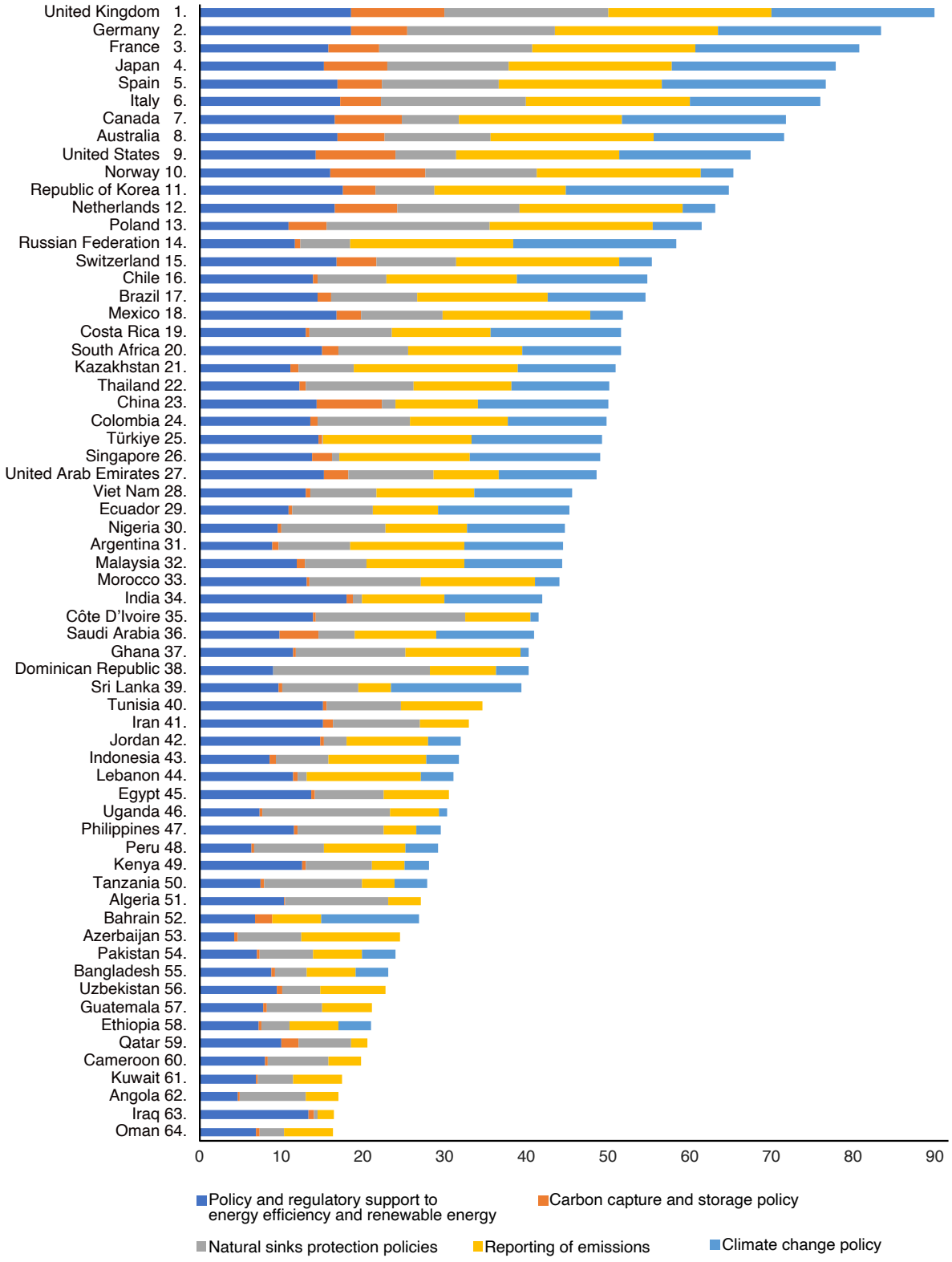
Figure 6. 2022 CCE Enablers scores.



Source: Authors' construction.

Note: The length of the bar indicates the Enablers sub-index score. Different colors display each dimension's contribution to the total.

Figure 7. Policies and regulation dimension scores.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

Countries' average scores are the highest on energy efficiency and renewable energy support policies (61) and compliance with United Nations GHG emissions reporting guidelines (59). Overall, countries receive significantly lower scores (12 on average) on CCS policy. This reflects both the low level of attention these technologies still receive in the majority of countries and the long way even top-scoring countries like Norway (58) and the United Kingdom (57) still have to go before having robust policy frameworks in place in this area.

Technology, knowledge and innovation: This dimension comprises six indicators that measure countries' progress on the creation, distribution and absorption of knowledge. Based on some estimates (IEA 2021, 96), up to 75% of the cumulative GHG emissions reductions required to collectively meet net-zero by mid-century are not yet commercially mature. Research and development (R&D) and technology diffusion therefore remain crucial enablers for CCE transitions.

On average, countries score the highest on indicators measuring domestic technological collaboration (university-industry collaboration and higher industries' economic contribution, 46 and 44, respectively) (Figure 8). They score lower, on average, on knowledge creation-related indicators (R&D expenditure, clean energy technology patents and academic research intensity, 28, 11 and 17, respectively), and on international high-technology interaction (measured by exports and imports of high technology, 20, on average).

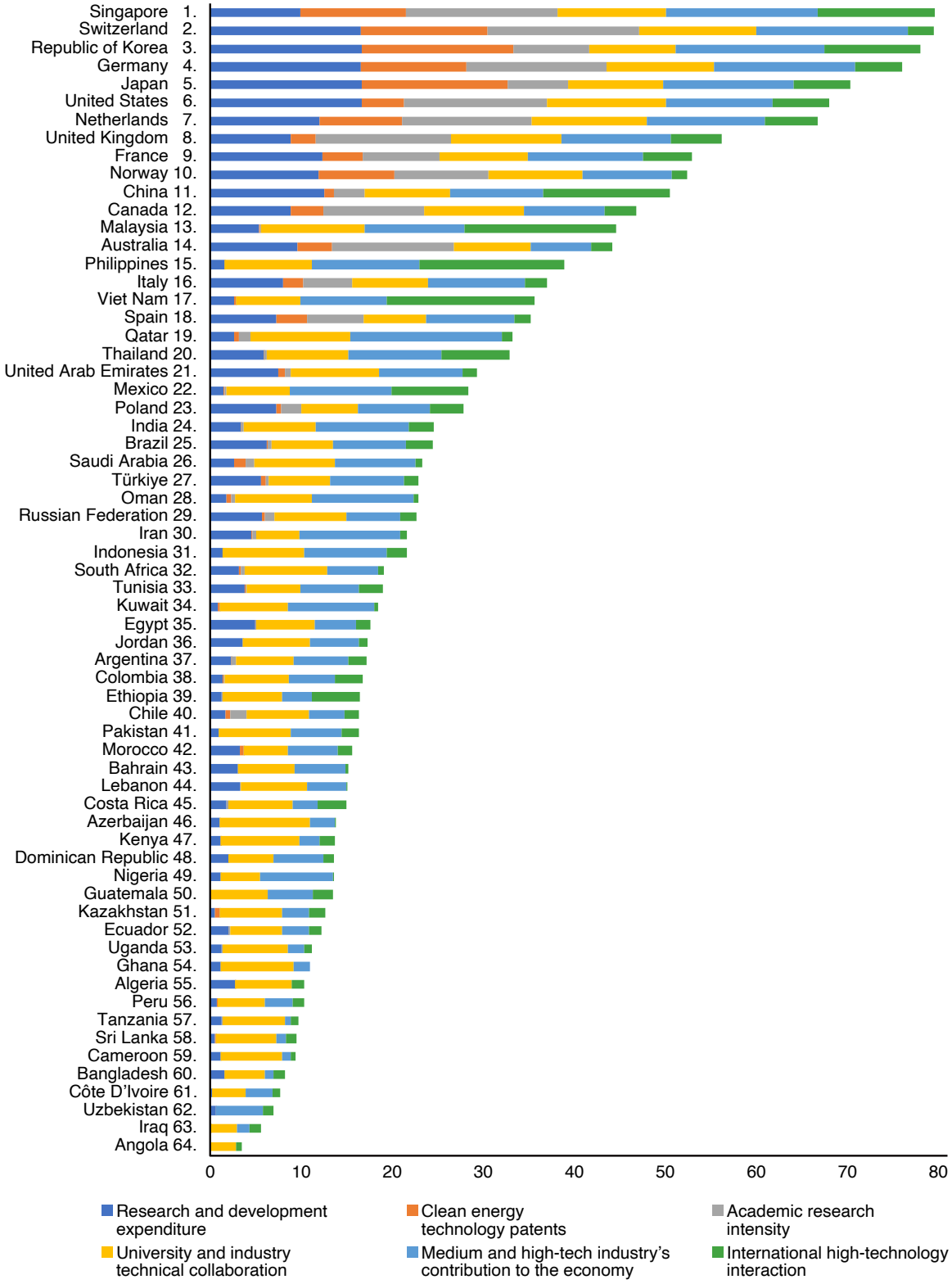
Within the top-five in this dimension are three Asian countries: Singapore, the Republic of Korea and Japan. A notable characteristic of this dimension – similar to the policy and finance dimensions – is that the five worst performing countries are not low-income countries. The gap between the top and bottom performers – Singapore and Angola – is equally wide as under the policy dimension, at 76 points.

Finance and investment: The five indicators under this dimension include both CCE-specific metrics, namely the levels of CCE technology investments and sustainable bond and loan issuances (the latter being measured with the indicator 'access to sustainable finance') and use of carbon pricing instruments. They also include more generic enabler metrics that gauge countries' overall financial development levels, and their international financial connectedness.

On average, countries score lower on the two CCE-specific financing indicators (27 on CCE investments and 17 on sustainable finance) than on the two generic enabler metrics (45 on financial development and 35 on international financial connectedness) (Figure 9). On the carbon pricing indicator, which rewards countries that have a regulated carbon pricing system in place (tax, cap and trade, or baseline and credit), 31 out of 64 score a zero – a share that is expected to gradually decrease going forward.

The gap between the top and bottom performers, Netherlands and Algeria, is the widest of all five dimensions, namely 83 points. In addition, this dimension – similar to the technology dimension – is characterized by extremely low scores toward the bottom of the distribution, which draws attention to the urgent need to enhance the enabling conditions for transition finance in many developing countries.

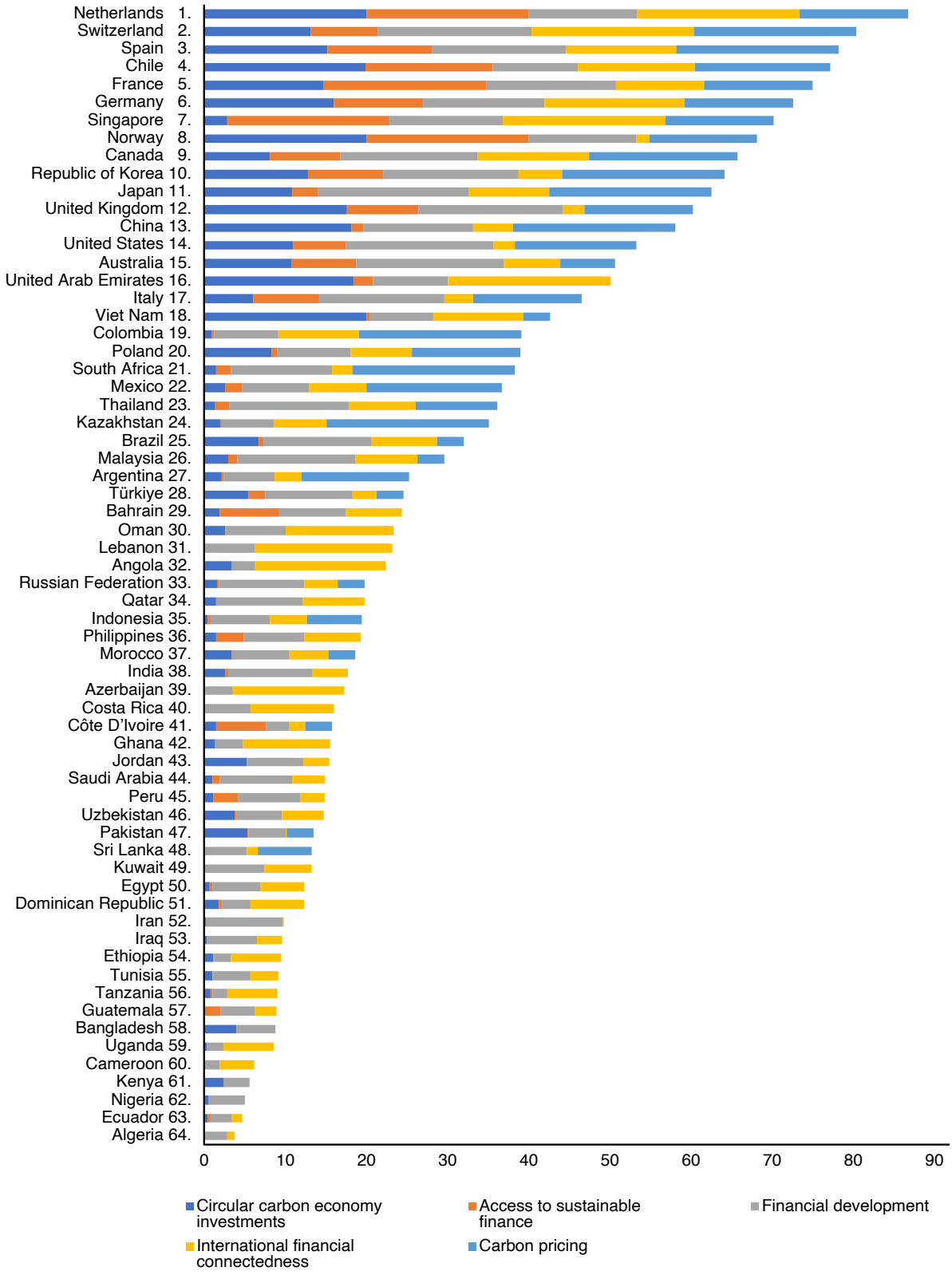
Figure 8. Technology, knowledge and innovation dimension scores.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

Figure 9. Finance and investment dimension scores.



Source: Authors' construction.

Note: The length of the bar indicates the Enablers sub-index score. Different colors display each dimension's contribution to the total.

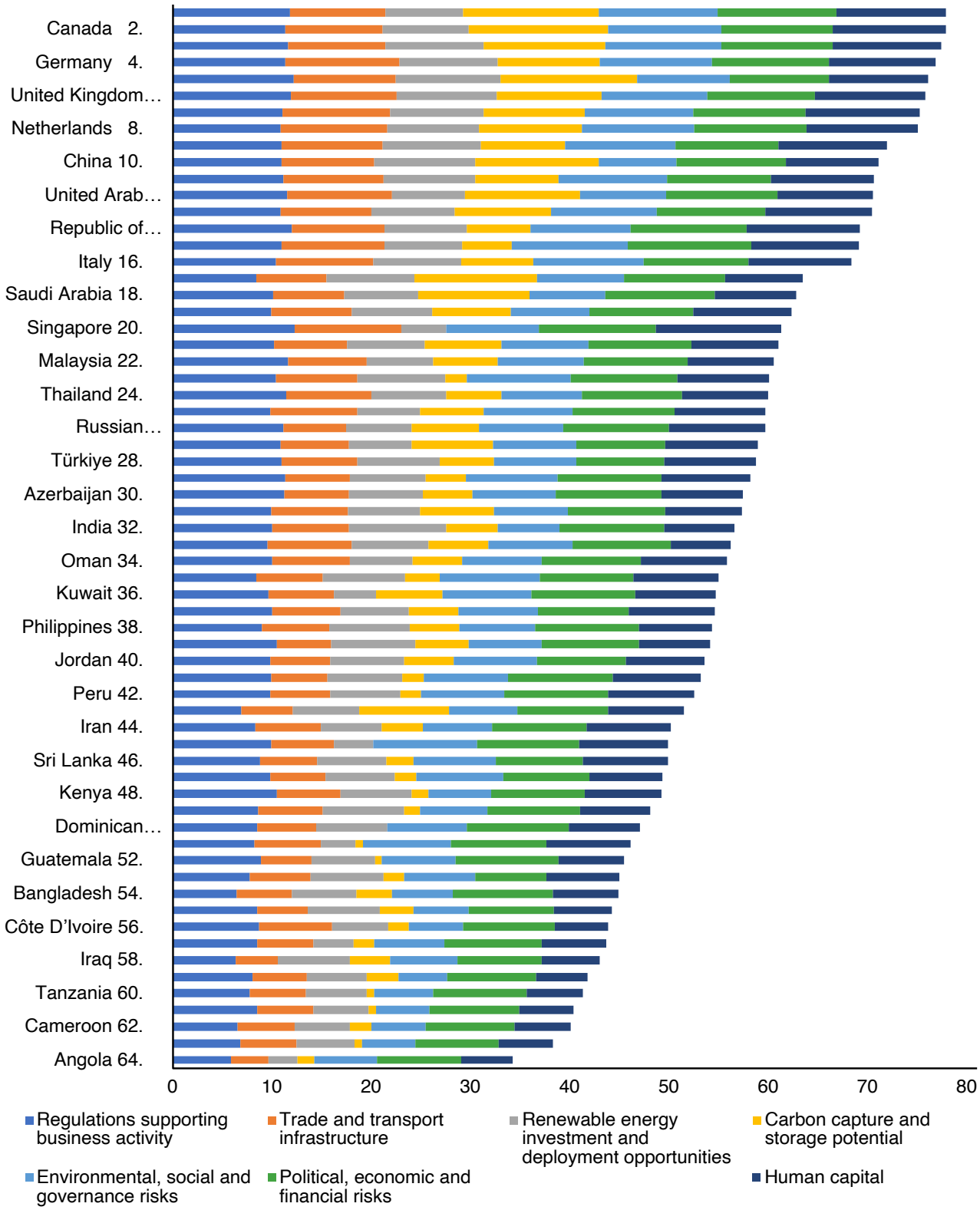
Business environment: This dimension uses seven indicators to measure enabling business environments. The top performers in this dimension are, again, industrialized countries, while the five lowest performers are all from Sub-Saharan Africa (Figure 10). CCE-specific metrics focus on renewable energy investment and deployment opportunities, the development of CCS resources (through an indicator titled 'CCS potential'), and environmental, social and governance risks. More generic metrics under this dimension gauge regulations supporting business activity; trade and transport infrastructure; political, economic and financial risks; and human capital. On average, countries score the lowest on the development of CCS resources (40), and the highest on business regulations (69).

The average score of the business environment dimension (57), similar to system resilience (58), is significantly higher than those of the other three dimensions (28–44). The difference between the top and bottom scores on this dimension is the narrowest of all CCE Enabler dimensions (44).[5]

System resilience: The final dimension brings together seven energy system-specific and broader sustainability indicators. The former category includes indicators measuring energy security (share of fuel imports in total imports), energy infrastructure stability (power system interruptions), and energy equity (access and affordability). The latter comprise metrics on economic diversification, adjusted national income (per capita), particulate matter pollution (from both indoor and ambient sources) and climate change resilience. On average, countries fare better on the energy system indicators than the broader system indicators (Figure 11). On energy system stability, 51 countries out of 64 score higher than 80, while the remaining group of countries suffers from significantly more serious supply interruptions. On energy security, countries' scores are more evenly distributed, but a large number of developing countries continue to spend heavily on energy. On energy equity, various Sub-Saharan African and South Asian countries continue to face difficulties. On the other system indicators, it is worth highlighting that this same group of countries also suffers from the highest levels of health impacts from particulate matter pollution, a large share of which originates from energy production and consumption.

The top performing country on system resilience, Switzerland, achieves indicator scores of 72–100 across the seven indicators and has the highest aggregate score among all countries across all CCE Enabler dimensions (93). The second-highest scoring country, Norway, achieves 87 points, and the country at the bottom of the ranking, Pakistan, achieves 13, indicating again a very wide gap between the top and the bottom.

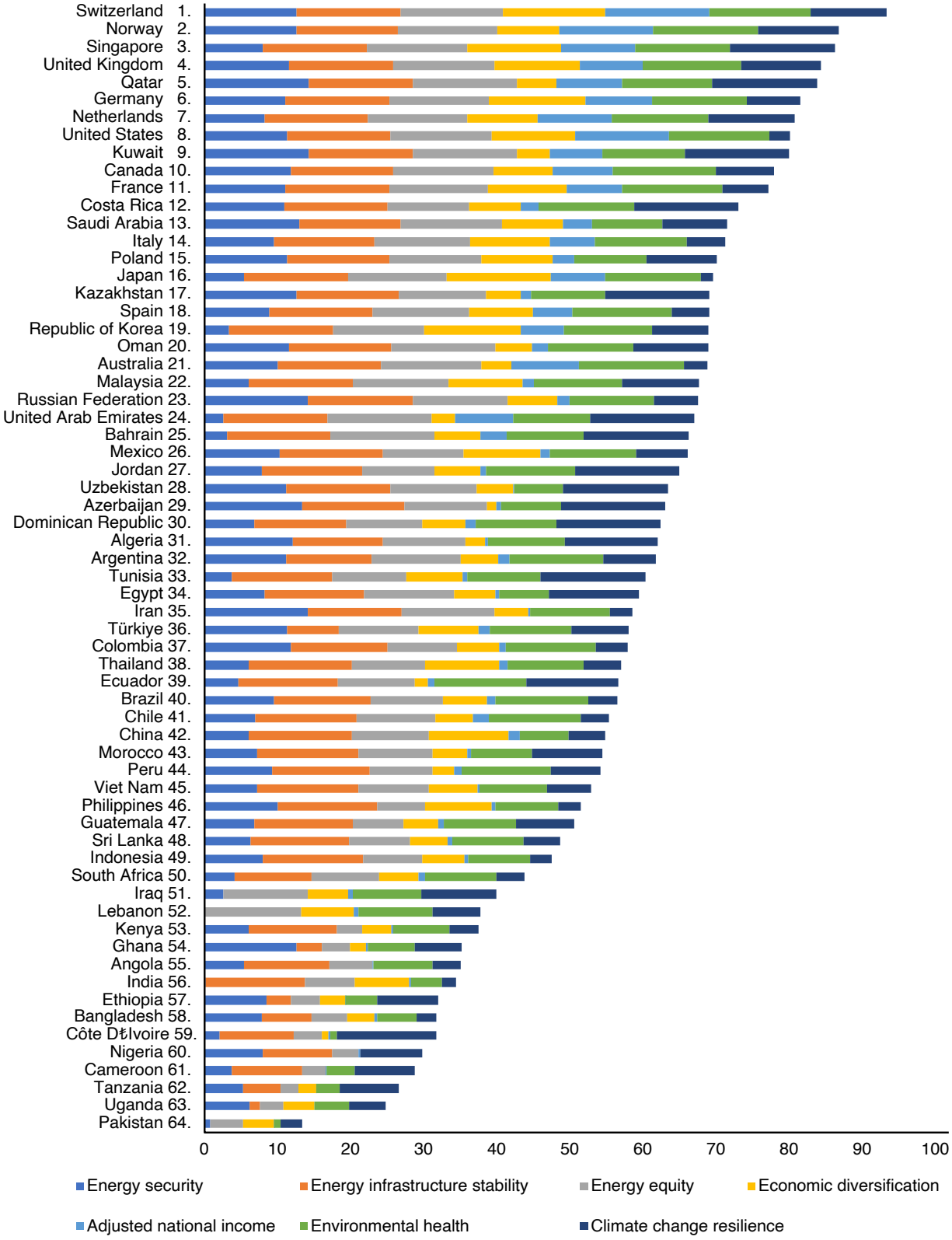
Figure 10. Business environment dimension scores.



Source: Authors' construction.

Note: The length of the bar indicates the Enablers sub-index score. Different colors display each dimension's contribution to the total.

Figure 11. System resilience dimension scores.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

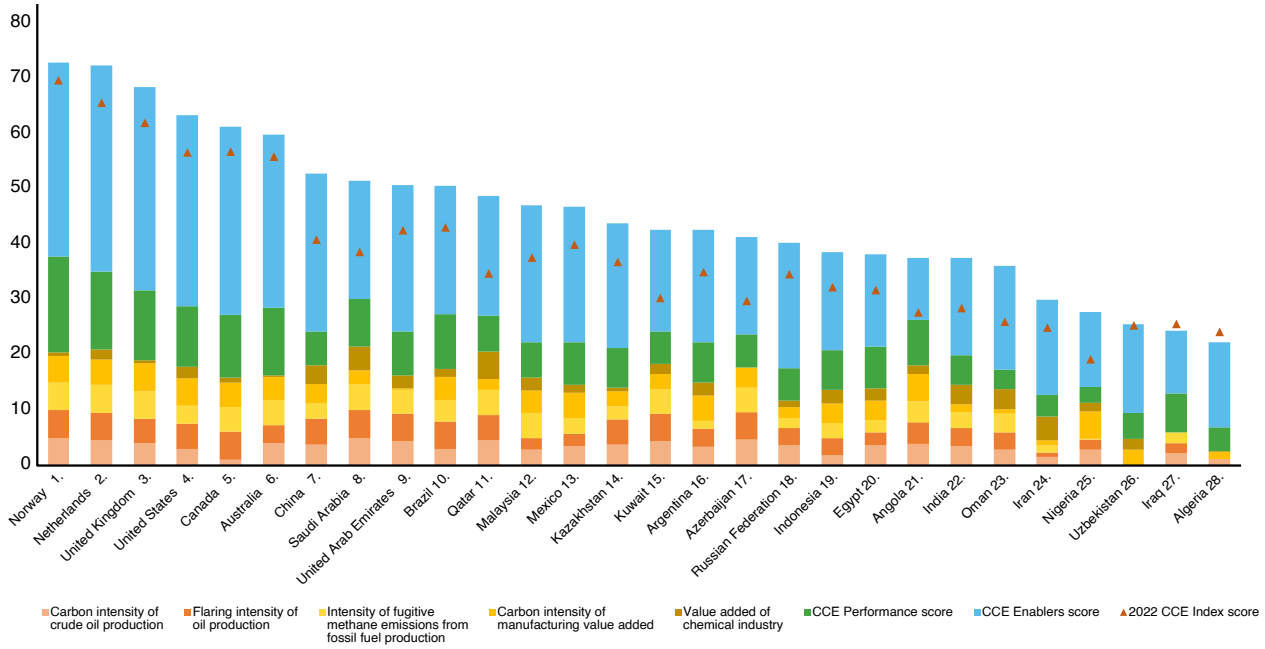
Oil Producers Lens

The Oil Producers Lens (OPL) provides an additional score for the 28 major oil and gas producing countries included in the 2022 CCE Index.[6] The OPL score is an aggregate measure of how well major oil- and natural gas-producing countries perform when their hydrocarbon and energy-intensive sectors are factored in. The OPL score not only enables more targeted comparisons among this group of countries, but its five performance indicators give insights into how they are managing carbon circularity at present. The total OPL score consists of the average of the five OPL Performance indicators (25%), the CCE Performance score (25%) and the CCE Enablers score (50%).

In the 2022 OPL ranking, the top three countries, Norway, the Netherlands and the United Kingdom, also receive some of the highest scores in the 2022 CCE Index (Figure 12). The three lowest-scoring countries on the OPL, Algeria, Iraq and Uzbekistan, rank in the lowest quadrant in the CCE Index. By and large, oil and gas producers score higher on the OPL than the total CCE Index, with the exception of the two bottom performers whose low performance on the five OPL indicators pushes their total OPL score even lower.

The five OPL Performance indicators comprise industrial intensity metrics that measure both the carbon circularity performance of the 28 countries' oil and gas industries (the carbon intensity of oil production, the intensity of gas flaring in oil production and the intensity of fugitive methane emissions from fossil fuel production) and that of the manufacturing sector (the carbon intensity of value added). They also contain a proxy for value generation from current and future CCE assets, such as the chemicals industry (GDP value added). On these five metrics, Saudi Arabia (86), the Netherlands (84) and Qatar (82) score the highest, whereas Algeria (10), Uzbekistan (19) and Iraq (24) score the lowest.

Figure 12. 2022 CCE Oil Producers Lens scores.



Source: Authors' construction.

Note: The length of the bar indicates the total OPL score. Different colors display each component's (indicators and sub-indices) contribution to the total.

Further Analysis: Reference Group Comparisons and Changes Over Time

The CCE Index results can also be examined in different reference groups to enable more meaningful comparisons. This section presents two examples: regional groups and income groups. The CCE Index web portal (https://cceindex.kapsarc.org) allows for further comparisons both within groups and among individual countries.

From 2022 onwards, the CCE Index will also provide cumulative scores for all years since 2021. This will enable analyses of changes of country scores over time. This section provides a high-level overview of these changes from 2021 to 2022 for the total CCE Index score and the two main sub-indices.

Country Reference Groups in 2022 CCE Index

As shown in Figure 13, there is still great variation in country scores when examined at a regional level, particularly in Europe and Central Asia. On average, countries from North America, and Europe and Central Asia score the highest in the total 2022 CCE Index (57 and 49, respectively). East Asia and the Pacific (43), Latin America and the Caribbean (37) and the Middle East and North Africa (31) fall in the middle, and South Asia (26) and Sub-Saharan Africa (23) score the lowest, on average.

Figure 14 presents the 2022 CCE Index countries and scores in an income group context (and OECD membership status). As expected, a higher income translates, on average, into a higher CCE Index score. However, even here, there is a wide variation in most groups between top and bottom performers.

Changes in Scores in 2021–2022

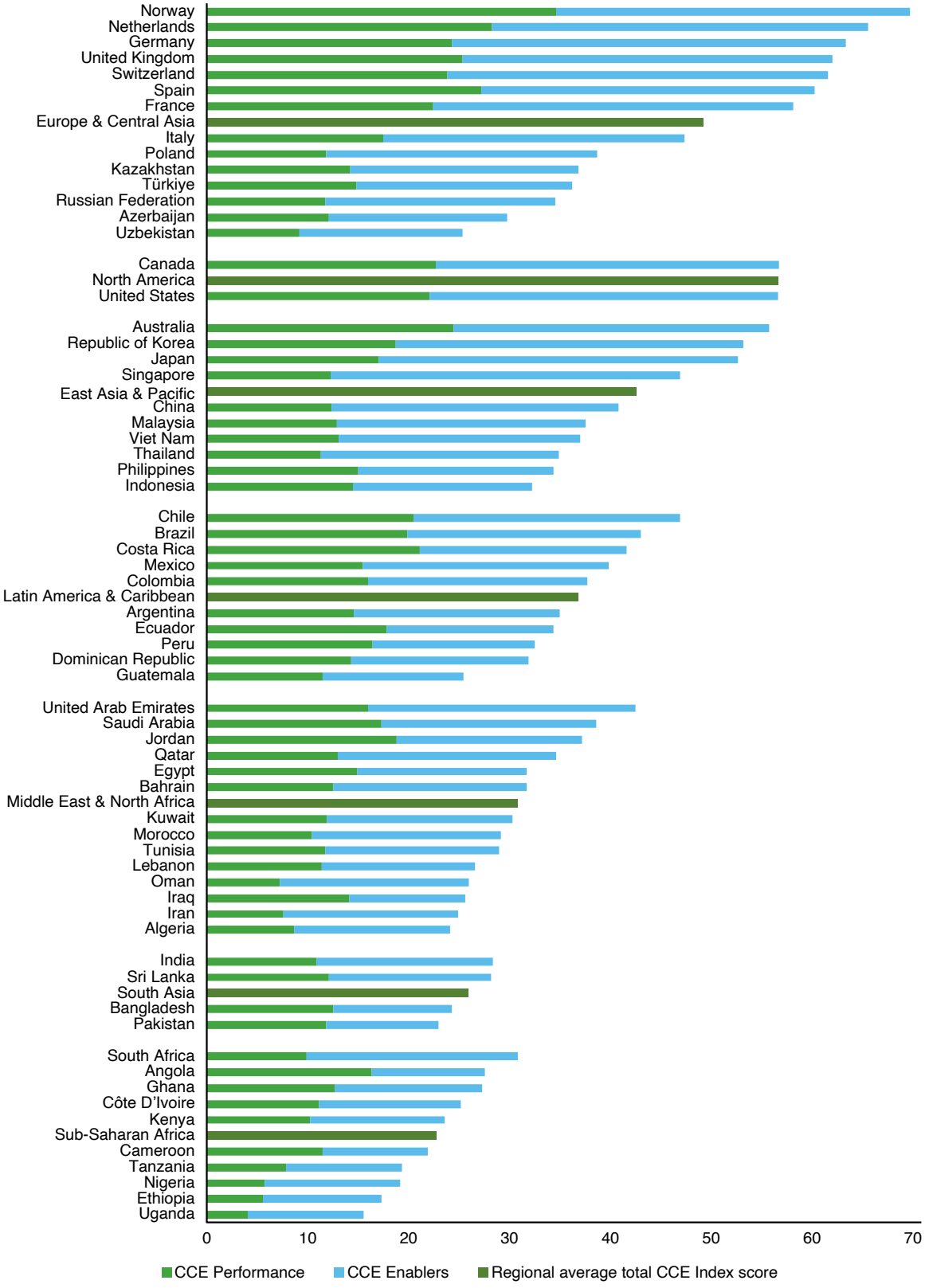
An important update introduced in the 2022 CCE Index is the availability of comparable scores for the previous edition. For this edition, the 2021 CCE Index scores have been recalculated to account for the larger number of countries (64 instead of the original 30 in the 2021 edition) and updates to the index framework. From 2022 onward, each new edition of the index will also provide updated scores for all previous CCE Index editions, which will allow for comparisons over time (see Appendix 1 for further details).

This paper presents an overview of changes in countries' scores at the total CCE Index level, as well as on the two sub-indices. The full set of indicator-level values and scores of all countries, along with aggregate scores for the five CCE Enabler dimensions for both years (2021 and 2022), are available via the CCE Index web portal (https://cceindex.kapsarc.org/) in the 2022 CCE Index codebook and database Excel file. These can be used to develop further comparisons.

Total CCE Index scores: Compared with 2021, 57 countries improved their total CCE Index scores in 2022 (Figure 15). The largest improvers were Kazakhstan (6.99 points), Spain (6.19 points) and Australia (5.32 points). The discussion below will identify the drivers of these changes. The average increase of countries' scores between 2021 and 2022 was 1.36. Seven countries saw their scores deteriorate, but in all cases the change was less than 1 point.[7]

CCE Performance scores: Compared to 2021, the large majority of countries (54) improved their scores also on the CCE Performance sub-index (Figure 16).

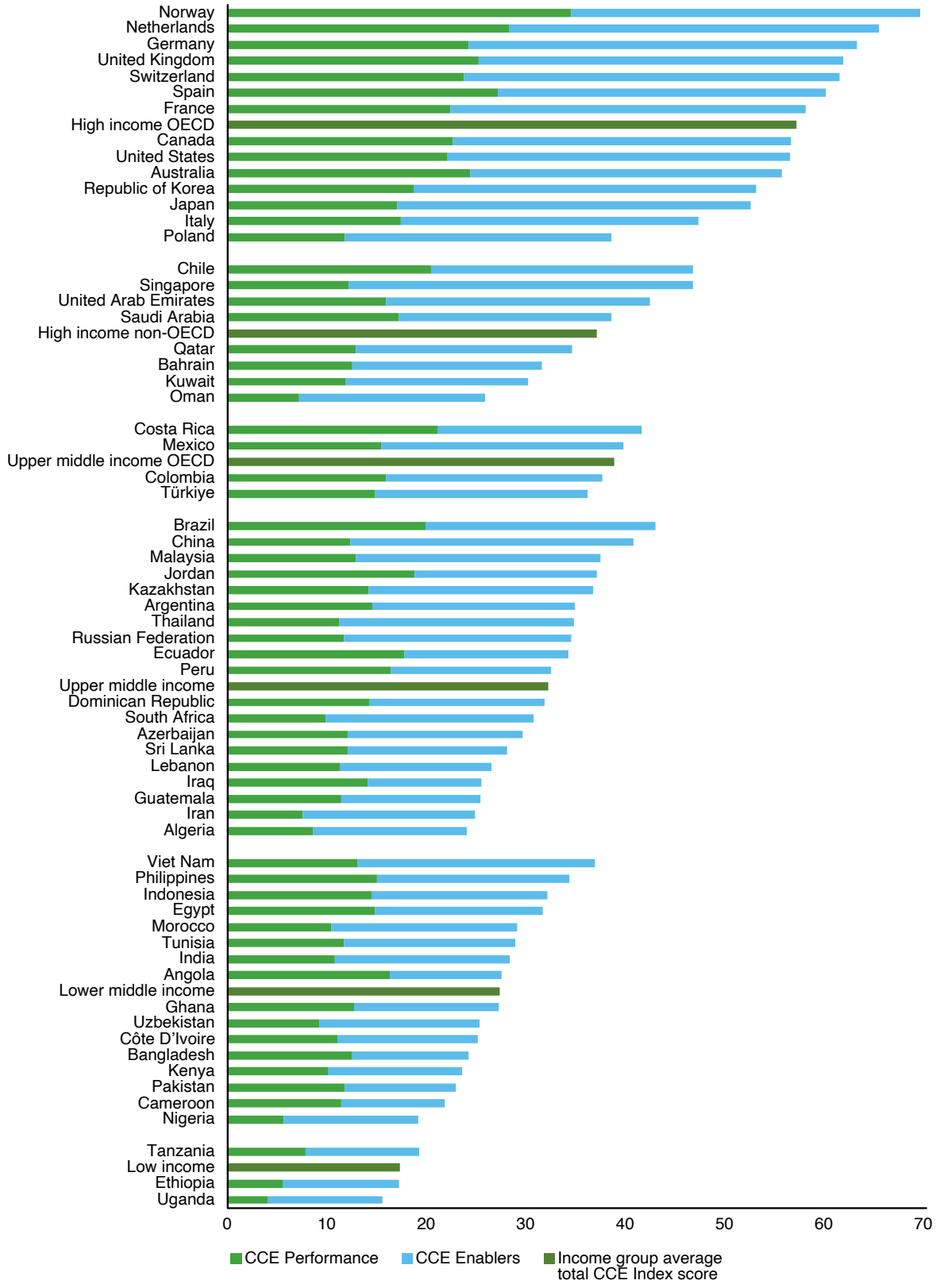
Figure 13. 2022 CCE Index scores visualized in regional groups.



Source: Authors' construction.

Note: The length of the bar indicates the total CCE Index score. Different colors display the contribution of each sub-index to the total.

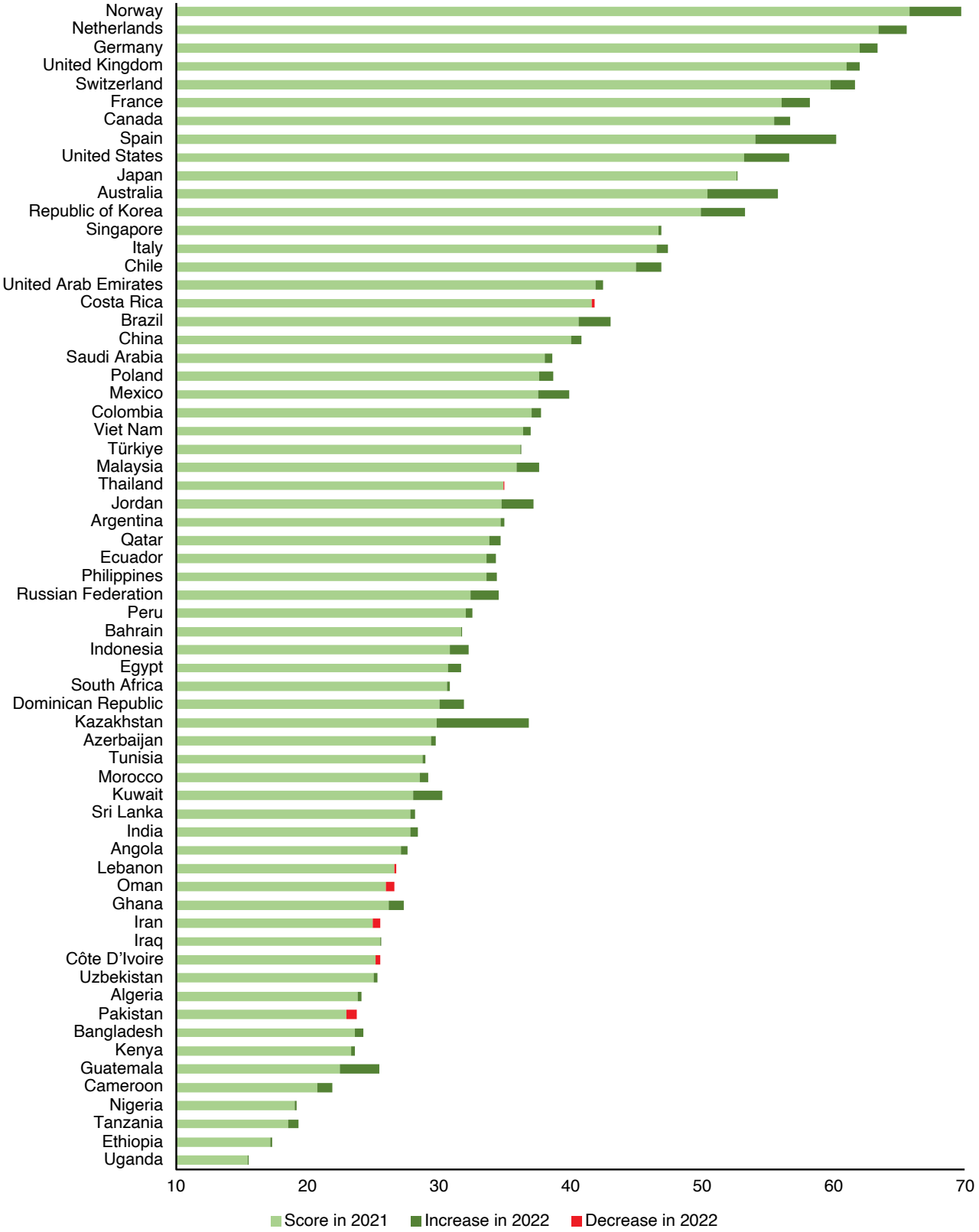
Figure 14. 2022 CCE Index scores visualized in income groups.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

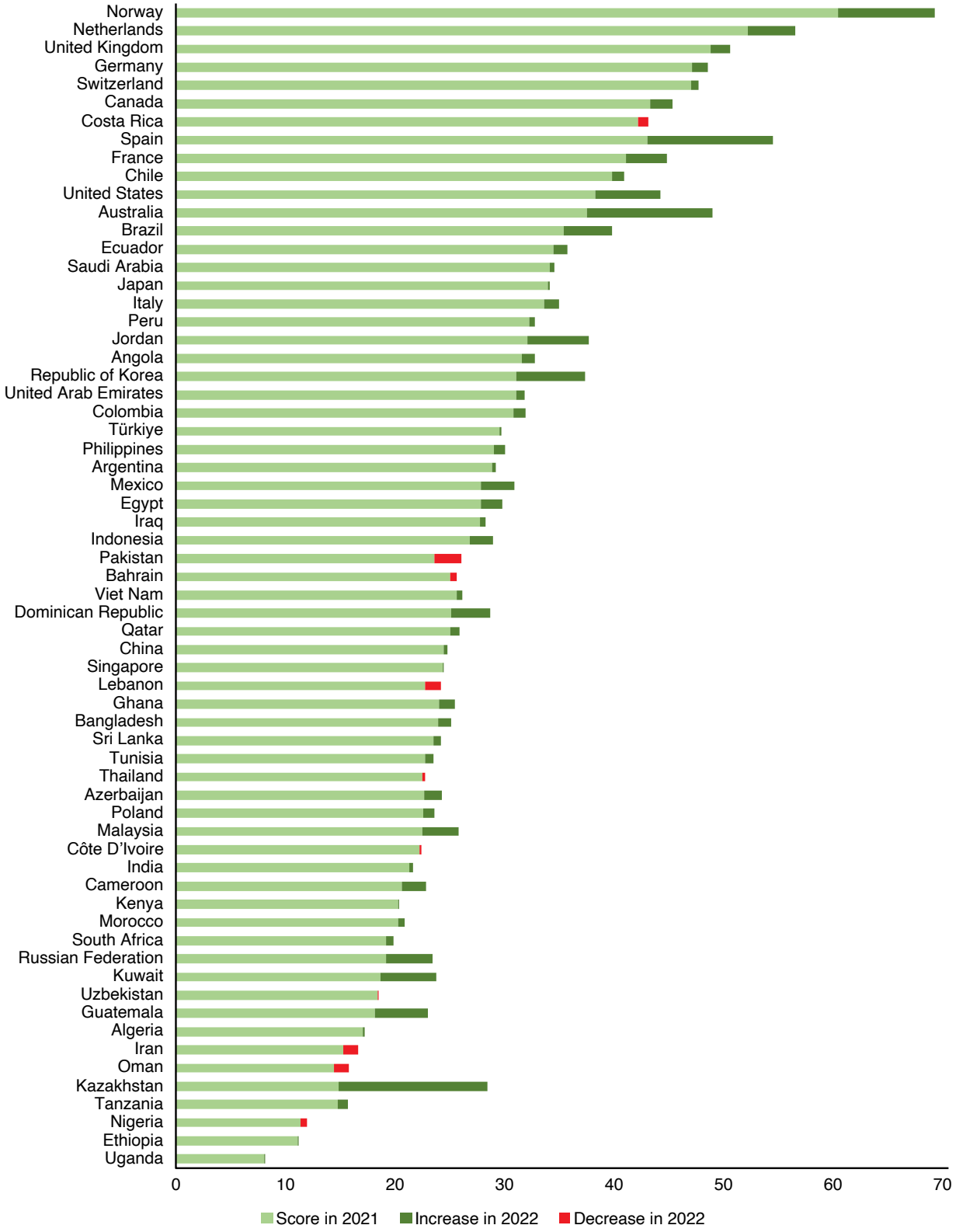
Figure 15. Changes in CCE Index total scores between 2021 and 2022.



Source: Authors' construction.

Note: The length of the bar indicates the total CCE Index score. Different colors display the contribution of each sub-index to the total.

Figure 16. Changes in CCE Performance scores between 2021 and 2022.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

Several countries increased their Performance scores by more than five points year-on-year. These were: Kazakhstan (13.59), Australia (11.45), Spain (11.43), Norway (8.78), the Republic of Korea (6.29), the United States (5.90) and Kuwait (5.12). For Kazakhstan, the major driver of its significant score increase was the addition of a 20-gigawatt (GW) electrolysis complex – historically unprecedented in scale – to its green hydrogen project pipeline. Spain, Norway and the Republic of Korea similarly added to their green hydrogen pipelines. Australia's improvement was driven by two indicators: first, a massive increase in its CCUS pipeline (comprising four large-scale CCS projects each with a storage capacity of 4.5–10 million tonnes of carbon dioxide per year) and, second, a fall in the share of coal in its electricity mix. The United States also increased its CCUS project pipeline. In Kuwait, a major fall in the share of oil and a simultaneous increase in the share of electricity in its total energy mix in 2020 drove the increase.

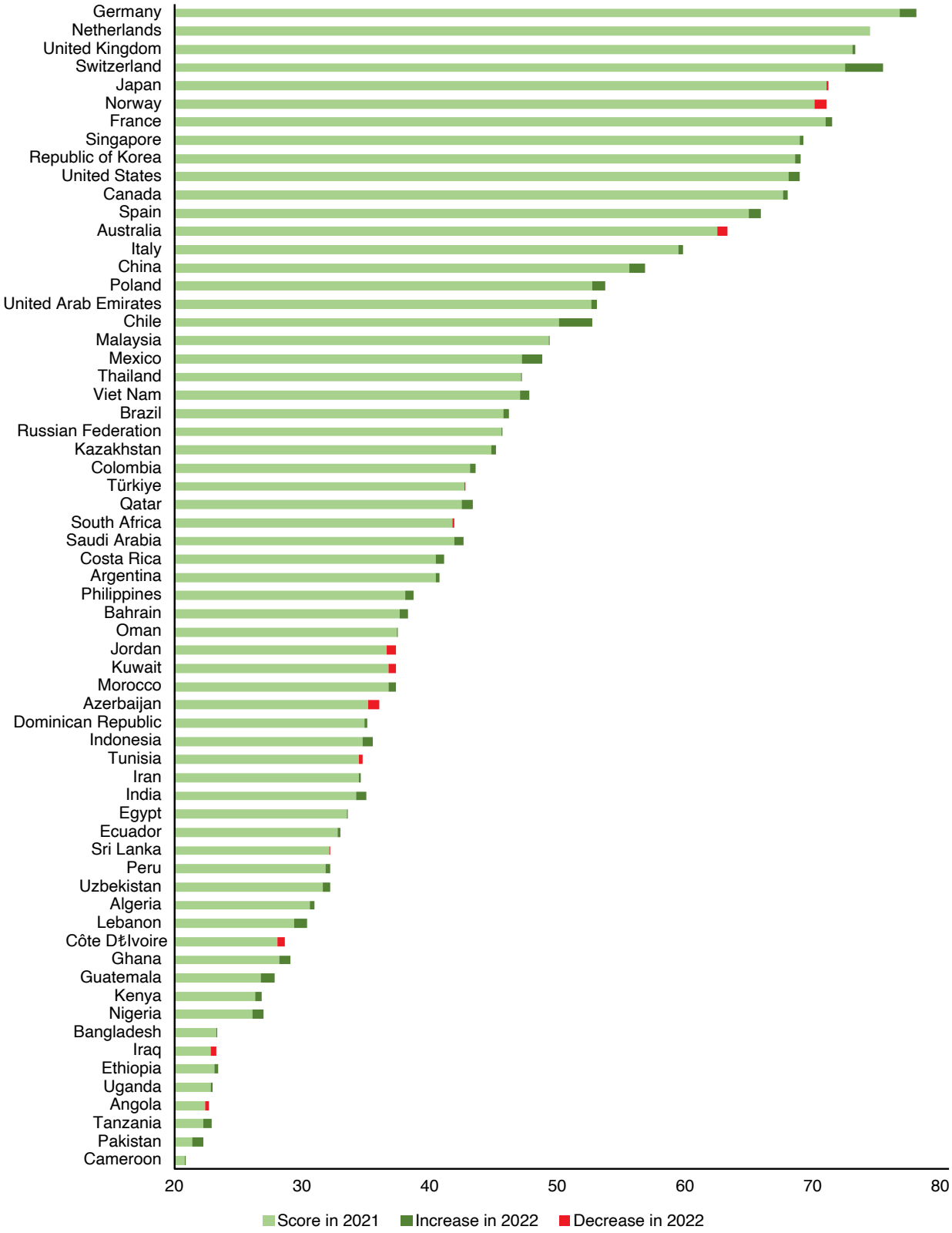
The average increase of countries' scores between 2021 and 2022 was 2.46. Ten countries saw their scores deteriorate, with Pakistan falling the most (2.44). The share of oil and coal in Pakistan's electricity mix, which had been falling for years, saw an increase in 2020, resulting in a major drop in its score on the fuel switching indicator.[8]

It is worth noting that the CCE Index has a data lag, as country comparison composite indicators generally do, which for this edition is often two years.[9] Data for five of the CCE Performance indicators (energy efficiency, renewable energy, electrification, nuclear energy and fuel switching) used for the 2022 scores is from 2020 and, consequently, data used for the 2021 scores is from 2019. This means that any impact of the first year of the COVID-19 pandemic should be visible in country scores on these indicators. On average, however, countries' scores on all five indicators saw an increase (of 0.2 to 3.2 points). A closer look at individual countries' scores, however, is likely to reveal more year-on-year variation, given the exceptionality of the pandemic. Only longer time series, however, will eventually allow to distinguish between the short-term and long-term impacts of the pandemic on countries' CCE performance – and their CCE enablers.

CCE Enablers scores: Compared with the CCE Performance sub-index, the Enablers sub-index has many more indicators (eight versus 30), which could be expected to lead to smaller changes over time (as the likelihood of indicators 'cancelling each other out' increases). More importantly, however, in most cases, enablers by their very nature take a longer time to be enhanced as they often require various simultaneous interventions and efforts.

Reflecting this, the majority of countries (51) improved their CCE Enablers scores between 2021 and 2022, with the average increase only 0.62 points (Figure 17). Only Switzerland (2.99) and Chile (2.66) increased their scores by more than two points. In both cases, higher scores from the finance and investment dimension drove the increase. For both, increases in CCE investments and in foreign direct investment flows contributed to this, and in the case of Chile, the introduction of a new carbon crediting mechanism also raised its score. The 13 countries whose scores deteriorated similarly saw only minor decreases of one point at most.[10]

Figure 17. Changes in CCE Enablers scores between 2021 and 2022.



Source: Authors' construction.

Note: The length of the bar indicates the Performance sub-index score. Different colors display each indicator's contribution to the total.

Conclusion

The 2022 edition extends the coverage of the CCE Index to 64 countries, which together cover most of the global economy and GHG emissions. They also represent diversity in terms of both regional representation and socioeconomic development. The purpose of the index is to provide concrete metrics that help make the CCE concept more tangible and provide quantitative metrics that enable energy and climate stakeholders worldwide to examine country performance and transition potential in various contexts. Single-country decomposition analyses can be used to stimulate discussions on policy options and system-wide approaches to designing energy transitions; reference group comparisons can be employed to identify strong performers (that similar countries can learn from) or weaknesses in a country's performance (where policy attention can be focused); and big picture, global analyses can be used for discussions about how global cooperation around net-zero transitions should be structured so as not to leave any country behind.

The CCE Index will continue to be updated regularly and revised to accommodate for new or better-quality datasets as they become available or new ways to measure the CCE. The index will only succeed if it is tested, used and reviewed by knowledge and policy stakeholders worldwide. The CCE Index team welcomes continuous feedback, questions and suggestions relating to the use and utility of the index in diverse countries and contexts.

We invite you again to visit the CCE Index web portal to explore and compare countries and their indicator scores and values in more detail. All underlying indicator data and methodological details are available for viewing and downloading via the portal, https://cceindex.kapsarc.org.

Appendix 1. Country Selection Criteria and Index Framework Updates in the 2022 Edition

This section presents the methodological updates made in the 2022 edition of the CCE Index. The full methodology is presented in KAPSARC Methodology Paper, "The Circular Carbon Economy Index 2021 – Methodology" (Luomi, Yilmaz, and Alshehri 2021a).

Country Selection Criteria

With the aim of increasing the number of countries covered by the CCE Index to add geographic and socioeconomic diversity, and to cover most of the world's GHG emissions and GDP, the 2022 edition applied the following criteria for country selection:

1. An average population of at least 1 million between 2018 and 2020, based on the World Bank Development Indicators database (World Bank 2022).

2. The 10 largest economies from each World Bank region (or all, if a region has fewer than 10 countries), based on the country's average GDP (current US$) for 2018–2020 from the World Bank Development Indicators database (World Bank 2022).

3. The top-30 largest oil and gas producing countries based on their average production between 2018 and 2020 (million tonnes of oil equivalent) based on the BP Statistics database (BP 2022).

4. The availability of 80% or more indicator values. (Based on this criterion, the following countries that met the other criteria were excluded: Afghanistan, Benin, the Democratic Republic of the Congo, Gabon, Libya, Mauritania, Nepal, Palestine, Somalia, Sudan, Syria, Turkmenistan, and Yemen).

5. Arab League member countries. (Since the CCE concept is gaining increasing traction in this region, the selection has been expanded to include as many countries from this group as possible, as long as the first and fourth inclusion criteria were met, to provide tools for related policy discussions).

Data Sources Used in the 2022 CCE Index

Data sources used in the 2022 CCE Index edition fall in the same categories as in the 2021 edition. Table A.1 shows the source organizations/authors of the datasets used in the 2021 CCE Index. More source and methodological information on each indicator are available via the CCE Index web portal.

Table A.1. Data sources used in the CCE Index.

Type of data source	Data source (organization/author)
Official statistics/data	Food and Agriculture Organization of the United Nations (U.N.); International Energy Agency; International Monetary Fund; U.N. Department of Economic and Social Affairs; U.N. Educational, Scientific and Cultural Organization Institute for Statistics; U.N. Framework Convention on Climate Change; U.N. Industrial Development Organization; U.N. Statistics Division; World Bank (including the Energy Sector Management Assistance Program, TCdata360), World Intellectual Property Organization (including Cornell University and INSEAD)
Data from research organizations and peer-reviewed publications	Eckstein, Künzel, and Schäfer (2021); Energy & Climate Intelligence Unit; Global CCS Institute; Harvard Growth Lab; Institute for Health Metrics and Evaluation; Jing et al. (2020); Springer Nature; Wolf et al., (2022); World Energy Council
Data from corporate providers	Bloomberg; Enerdata; EY; Global Risk Profile; PRS Group

Data Coverage Requirement Exceptions

- As established in the 2021 edition, a key criterion for indicator inclusion is that at least 80% of the data points are available for the countries included in the index. Missing values are imputed based on the same logic as in the 2021 edition (see Luomi, Yilmaz, and Alshehri 2021a). With 64 countries in the overall CCE Index and 28 countries receiving OPL scores, the thresholds for indicator inclusion (excluding imputations for 0) in the 2022 CCE Index are therefore data availability for 52 countries for the total CCE Index and 23 countries for the OPL. Only two exceptions to the inclusion rule were made:

- For "carbon capture and storage policy," which has values for 50 countries, imputations for missing values were made based on regional/income group averages, except for four Latin American and Caribbean countries (Costa Rica, the Dominican Republic, Ecuador and Guatemala) for which score estimates were received from the Global CCS Institute.

- For "carbon capture and storage potential," which has values for 45 countries, imputations were made based on estimates received from the Global CCS Institute, except for Bahrain, which was imputed based on its regional/income group average.

Main Changes to the Indicator Framework

A number of updates were introduced to the indicator framework as part of the development of the 2022 edition of the CCE Index. These were necessary to accommodate the higher country coverage and to maximize the likelihood of data updates being available for future index editions.

Some updates were made in order to improve indicators. For example, under CCE Performance, the renewable energy indicator no longer includes firewood and waste, as the former is a major human health hazard and contributor to deforestation, and the latter, as reported by the data source, includes both renewable and non-renewable waste. The other major example under CCE Performance is the natural sinks indicator which now also incorporates a measure of a country's forest area (as a share of its total land area), and a measure of how well the country is preserving its natural sinks.

In addition, two dimensions of the CCE Enablers sub-index were reorganized to improve the conceptual consistency of what these areas measure. Energy system-related indicators were separated from the 'business environment' dimension and regrouped together with broader system stability and sustainability indicators into a 'system resilience' dimension.

Under CCE Enablers, new or changed metrics were applied to 'carbon capture and storage policy,' 'climate change policy,' 'financial development,' 'carbon pricing,' and 'environmental health.' A new indicator was introduced to measure 'political, economic and financial risks,' while 'employment' and 'quality of governance' indicators were omitted as too generic and redundant.

Out of the five Oil Producers Lens enabler indicators in the 2021 edition, data updates for one were discontinued and data coverage for the other was insufficient for inclusion in 2022. The other three indicators were redistributed under other CCE Enablers dimensions as they can equally be used to measure countries with smaller or no oil and gas

industries, namely 'carbon capture and storage potential,' 'environmental, social and governance risks,' and commitment to net-zero emissions.

In addition, minor adjustments were made to indicator calculation methods, such as years of data used. In other cases, there were changes in the underlying data, such as for example the inclusion of new technologies under 'CCE investments' by the data source.

A detailed description of all indicators and related methodological information, as well as data on country availability, years of data used, minimum and maximum values applied and the logic for setting these and the direction of the indicator (ascending/descending) are available in the 2022 CCE Index codebook and database Excel file, which also contains all indicator values and scores. The file can be downloaded via the CCE Index web portal: https://cceindex.kapsarc.org/cceindex/downloads.

Aggregation and Weighting Logic

The major change in the 2022 CCE Index compared with the 2021 edition is the omission of the OPL Enablers dimension due to the discontinuation of datasets underlying two of its indicators and a lack of alternatives. The remaining three indicators, which are also applicable to non-oil producing countries, were reallocated to the CCE Enablers sub-index. Otherwise, the aggregation and weighting logic in 2022 remains the same (see Figure A.1.).

Figure A.1. Aggregation and weighting logic of the 2022 CCE Index.

Index level	Sub-index level	Dimension/indicator level					No.
CCE Index	Performance score (50%)	Performance indicators (6.25% each)					8
	Enablers score (50%)	Enablers dimensions					30
		Policies and regulation (10%)	Tech., knowledge and innovation (10%)	Finance and investment (10%)	Business environment (10%)	System resilience (10%)	
Oil Producers Lens	Oil Producers Lens Performance score (50%)	Performance indicators (3.13% each)					8
		Oil Producers Lens Performance indicators (5% each)					5
	Enablers score (50%)	Enablers dimensions					30
		Policies and regulation (10%)	Tech., knowledge and innovation (10%)	Finance and investment (10%)	Business environment (10%)	System resilience (10%)	

Source: Authors' construction.

Start of Multi-Year Score Generation

Starting with the 2022 Edition, the CCE index provides scores that are comparable over time. In 2022, scores are provided for 2021 and 2022. First, to ensure the comparability of the scores, the minimum and maximum limits for the scoring range are determined by using countries' indicator values for the first year of the index (i.e., the 2021 edition). Subsequently, these limits are kept constant across the index years and editions. This approach relies on the assumption that these boundaries (i.e., technical/scientific/natural, or the average of the top/bottom three values) do not vary much on an annual basis. However, this assumption may be revisited in the future with the accumulation of longer time series.

Second, to ensure comparability over time, the scores for previous index editions are recalculated each year. In other words, the 2022 CCE Index edition contains recalculated scores and ranks for the 2021 CCE Index. This was necessary because 34 new countries were added to the index and changes were introduced across the indicator framework. Small changes are also expected to be introduced going forward. Recalculation is also beneficial for keeping the underlying data up-to-date, as data providers and sources often make retroactive revisions to their datasets.

Appendix 2. Validation, Including Robustness Tests

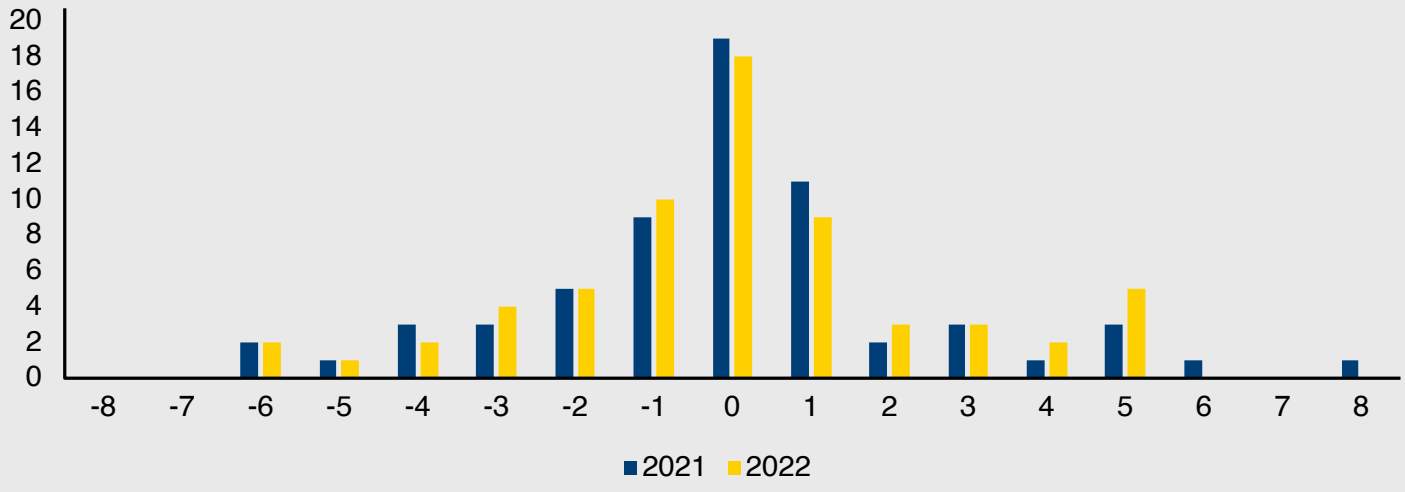
Robustness

The authors conducted a validity check for the 2022 results by using principal component analysis (PCA), an aggregation methodology widely used in index creation. In principle, the expectation is that the general distribution of scores and the associated rankings should not vary much based on the aggregation methodology. The PCA methodology relies on common behaviour (i.e., correlations) across the aggregated indicators, which would imply that, for instance, to score high on the CCE Enablers sub-index, a country would need to follow a common trend across the included dimensions. While such patterns are more common among the enabling factors (e.g., countries with stronger financial development tend to raise more funds from global markets, including environmental, social and governance [ESG] funds, and undertake more CCE investment), these patterns are less common for the CCE activities measured under the Performance sub-index given the CCE's emphasis on diverse and varied approaches across countries.

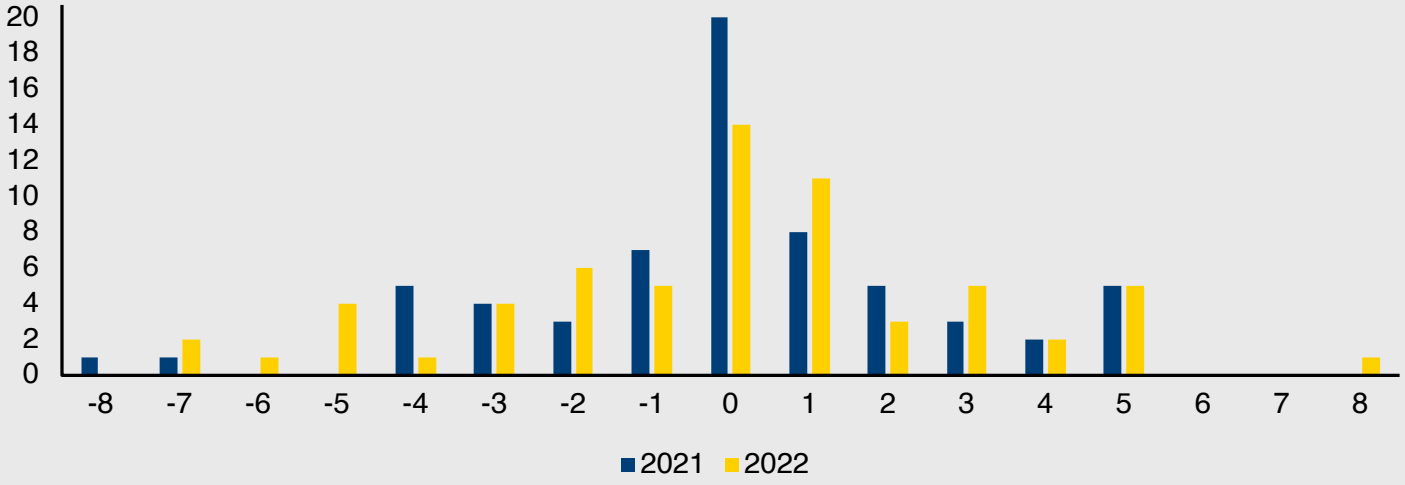
The authors, nevertheless, have applied PCA to the aggregation of both the CCE Performance and Enablers sub-indices, to produce the total CCE Index. To ensure comparability and consistency over time, factor loads are first estimated using the 2021 CCE Index indicators, which are then employed to compute the 2022 edition. The changes in rankings based on equal weighting and PCA are displayed in panels a-c of Figure A.2. Positive numbers imply higher ranks relative to our baseline methodology, while negative numbers imply the opposite.

Figure A.2. Changes in rankings when using PCA for aggregation (number of countries).

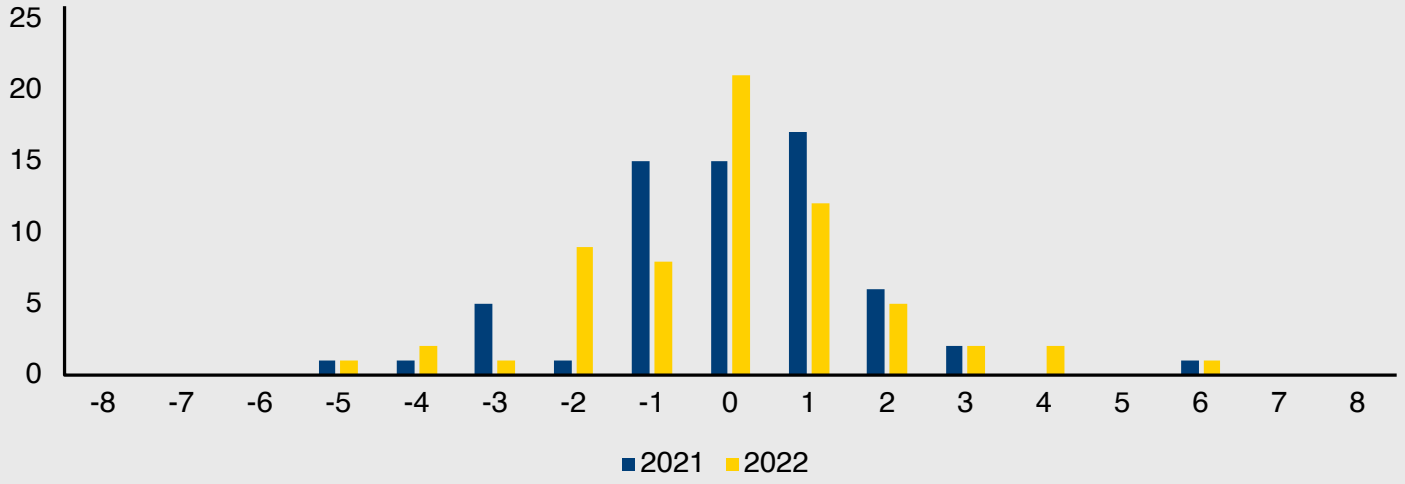
(a) Total CCE Index rankings



(b) CCE Performance sub-index rankings



(c) CCE Enablers sub-index rankings



Source: Authors' construction.

Note: The length of the bars indicates the direction and the magnitude of changes in country rankings if the aggregation methodology shifts from equal weighting to PCA. Positive numbers imply an improvement in the ranking and negative numbers imply a drop.

The results indicate significant overlaps across the two aggregation methods. In particular, when using the PCA methodology, approximately 60% of the countries either do not change their rank or the changes are minimal (±1) in the rankings of most countries (Figure A.2[a]). As displayed in the figure, similar trends are observed in both years of the index. When comparing the two components of the CCE Index, expectedly, there is less variation in the rankings for the CCE Enablers sub-index, based on the methodology change (Figure A.2[c]).

Cross-Validity Analysis

Ensuring that the CCE Index measures its intended conceptual focus is another crucial validity test. If the correlations between the individual indicators and the aggregated indicators are 1 (or above 0.9 according to Lafortune et al. [2018]), then a multicollinearity problem would arise. This would imply that some of the indicators or aggregated indicators are redundant or capture their conceptual focus weakly. Table A.2. presents the correlations across all the aggregated index components for the 2021 and 2022 scores. While the test was performed for all the indicators included in each sub-group, the results are not reported here, for brevity.

As shown in the table, no multicollinearity is observed from the results. It is worth noting that correlations across the CCE Performance indicators are significantly stronger across the indicators under each CCE Enablers dimension, while multicollinearity does not appear from the result. These results are statistically significant according to conventional levels.

Table A.3. Correlation matrices across aggregated sub-indices and dimensions.

(a) CCE Index 2021 components

		1	2	3	4	5	6	7
1	av_perf0100_2021	1.00						
2	av_opl_dim0100_2021	**0.56**	1.00					
3	av_policyind20210100	**0.65**	0.35	1.00				
4	av_techind20210100	**0.58**	**0.55**	**0.70**	1.00			
5	av_finind20210100	**0.71**	**0.55**	**0.80**	**0.81**	1.00		
6	av_beiind20210100	**0.67**	**0.50**	**0.81**	**0.81**	**0.84**	1.00	
7	av_seeind20210100	**0.59**	0.42	**0.56**	**0.66**	**0.62**	**0.79**	1.00

(b) CCE Index 2022 components

		1	2	3	4	5	6	7
1	av_perf0100_2022	1.00						
2	av_opl_dim0100_2022	**0.58**	1.00					
3	av_policyind20220100	**0.68**	0.38	1.00				
4	av_techind20220100	**0.58**	**0.57**	**0.69**	1.00			
5	av_finind20220100	**0.72**	**0.56**	**0.79**	**0.82**	1.00		
6	av_beiind20220100	**0.70**	**0.52**	**0.81**	**0.80**	**0.83**	1.00	
7	av_seeind20220100	**0.61**	0.44	**0.55**	**0.66**	**0.62**	**0.77**	1.00

Source: Authors' construction.

Note: All the bold correlation coefficients are statistically significant at the 1% level and the rest are statistically significant at the 5% level.

Appendix 3. 2022 and 2021 CCE Index Results

2022 CCE Index Results	Total CCE Index		Performance sub-index		Enablers sub-index		Enablers dimensions										Oil Producers Lens (OPL)					
							Policies and regulation		Technology, knowledge and innovation		Finance and investment		Business environment		System resilience		Total OPL		Performance sub-index (with OPL)		OPL indicators	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Norway	69.68	1	69.25	1	70.12	7	65.31	10	52.33	10	68.16	8	77.93	1	86.85	2	72.83	1	75.54	1	81.84	4
Netherlands	65.53	2	56.58	2	74.48	3	63.12	12	66.75	7	86.73	1	75.11	8	80.70	7	72.36	2	70.23	2	83.89	2
Germany	63.33	3	48.56	6	78.10	1	83.46	2	76.04	4	72.54	6	76.87	4	81.58	6						
United Kingdom	61.98	4	50.63	4	73.33	4	90.00	1	56.19	8	60.18	12	75.85	6	84.41	4	68.40	3	63.48	3	76.33	5
Switzerland	61.59	5	47.67	7	75.52	2	55.39	15	79.47	2	80.29	2	69.13	15	93.32	1						
Spain	60.21	6	54.47	3	65.94	12	76.61	5	35.18	18	78.20	3	70.67	11	69.05	18						
France	58.16	7	44.80	9	71.52	5	80.73	3	52.86	9	74.94	5	71.95	9	77.10	11						
Canada	56.68	8	45.35	8	68.01	11	71.74	7	46.75	12	65.75	9	77.90	2	77.91	10	61.29	5	54.56	8	63.77	14
United States	56.59	9	44.21	10	68.96	10	67.39	9	67.94	6	53.24	14	76.15	5	80.06	8	63.34	4	57.72	5	71.22	9
Australia	55.74	10	48.94	5	62.54	13	71.57	8	44.19	14	50.59	15	77.46	3	68.86	21	59.79	6	57.04	6	65.13	12
Republic of Korea	53.21	11	37.39	15	69.04	9	64.78	11	78.00	3	64.16	10	69.24	14	69.00	19						
Japan	52.63	12	34.15	19	71.11	6	77.83	4	70.32	5	62.53	11	75.28	7	69.58	16						
Italy	47.37	13	34.93	17	59.81	14	76.00	6	37.02	16	46.45	17	68.39	16	71.22	14						
Chile	46.86	14	40.96	12	52.77	18	54.84	16	16.34	40	77.15	4	60.13	23	55.38	41						
Singapore	46.86	15	24.45	40	69.27	8	49.08	26	79.60	1	70.13	7	61.28	20	86.23	3						
Brazil	43.01	16	39.79	13	46.23	23	54.62	17	24.49	25	32.01	25	63.53	17	56.53	40	50.52	10	54.81	7	69.83	11
United Arab Emirates	42.48	17	31.86	23	53.10	17	48.65	27	29.30	21	50.02	16	70.54	12	67.01	24	50.75	9	48.40	13	64.94	13
Costa Rica	41.63	18	42.17	11	41.10	31	51.58	19	14.91	45	16.04	40	49.92	45	73.04	12						
China	40.83	19	24.77	39	56.90	15	50.02	23	50.44	11	58.08	13	71.10	10	54.88	42	52.75	7	48.60	11	72.44	8
Mexico	39.86	20	30.93	24	48.80	20	51.77	18	28.35	22	36.69	22	61.01	21	66.16	26	46.74	13	44.68	16	58.42	17
Poland	38.66	21	23.56	45	53.75	16	61.50	13	27.79	23	38.93	20	70.46	13	70.09	15						
Saudi Arabia	38.63	22	34.59	18	42.68	29	40.95	36	23.28	26	14.84	44	62.84	18	71.49	13	51.52	8	60.36	4	86.13	1
Colombia	37.75	23	31.89	22	43.61	26	49.77	24	16.74	38	39.03	19	54.62	37	57.90	37						
Malaysia	37.57	24	25.77	35	49.36	19	44.42	32	44.53	13	29.56	26	60.60	22	67.69	22	47.03	12	44.70	15	63.63	15
Jordan	37.17	25	37.67	14	36.66	38	32.01	42	17.27	36	15.37	43	53.62	40	65.03	27						
Viet Nam	36.99	26	26.16	33	47.81	21	45.64	28	35.62	17	42.62	18	62.32	19	52.87	45						
Kazakhstan	36.82	27	28.45	31	45.19	25	50.93	21	12.68	51	35.03	24	58.23	29	69.10	17	43.84	14	42.48	19	56.52	19
Türkiye	36.21	28	29.70	27	42.72	28	49.29	25	22.90	27	24.52	28	58.82	28	58.09	36						
Argentina	34.97	29	29.20	28	40.74	32	44.44	31	17.19	37	25.26	27	55.04	35	61.79	32	42.62	16	44.50	17	59.81	16
Thailand	34.87	30	22.50	51	47.24	22	50.19	22	32.92	20	36.09	23	60.00	24	56.98	38						
Qatar	34.66	31	25.91	34	43.40	27	20.59	59	33.18	19	19.70	34	59.72	25	83.79	5	48.76	11	54.13	9	82.34	3
Russian Federation	34.54	32	23.46	47	45.61	24	58.39	14	22.68	29	19.76	33	59.71	26	67.53	23	40.35	18	35.08	22	46.70	23
Philippines	34.37	33	30.03	25	38.72	33	29.53	47	38.90	15	19.28	36	54.35	38	51.51	46						
Ecuador	34.33	34	35.69	16	32.97	46	45.21	29	12.21	52	4.63	63	46.15	51	56.65	39						
Peru	32.51	35	32.80	20	32.21	48	29.20	48	10.34	56	14.80	45	52.56	42	54.16	44						
Indonesia	32.22	36	28.93	29	35.52	39	31.78	43	21.64	31	19.37	35	57.33	31	47.48	49	38.63	19	41.73	20	54.53	22
Dominican Republic	31.89	37	28.65	30	35.13	41	40.23	38	13.58	48	12.30	51	47.06	50	62.46	30						
Egypt	31.70	38	29.81	26	33.60	45	30.50	45	17.53	35	12.34	50	48.15	49	59.45	34	38.26	20	42.93	18	56.04	20
Bahrain	31.67	39	25.02	38	38.32	34	26.90	52	15.19	43	24.36	29	58.98	27	66.19	25						
South Africa	30.80	40	19.82	56	41.78	30	51.55	20	19.02	32	38.27	21	56.27	33	43.79	50						
Kuwait	30.28	41	23.78	43	36.77	37	17.47	61	18.45	34	13.25	49	54.67	36	80.01	9	42.68	15	48.58	12	73.39	6
Azerbaijan	29.73	42	24.26	41	35.21	40	24.50	53	13.77	46	17.24	39	57.48	30	63.05	29	41.37	17	47.53	14	70.80	10
Morocco	29.14	43	20.90	54	37.38	36	44.05	33	15.56	42	18.63	37	54.18	39	54.46	43						
Tunisia	28.99	44	23.49	46	34.49	44	34.67	40	18.98	33	9.15	55	49.35	47	60.31	33						
India	28.36	45	21.67	53	35.05	42	41.93	34	24.52	24	17.72	38	56.60	32	34.48	56	37.52	22	39.98	21	58.29	18
Sri Lanka	28.17	46	24.20	42	32.14	49	39.41	39	9.49	58	13.29	48	49.89	46	48.63	48						
Angola	27.58	47	32.73	21	22.43	62	17.01	62	3.43	64	22.40	32	34.26	64	35.05	55	37.54	21	52.66	10	72.58	7
Ghana	27.30	48	25.48	36	29.12	52	40.25	37	10.99	54	15.49	42	43.66	57	35.20	54						
Lebanon	26.57	49	22.75	50	30.39	51	31.07	44	14.97	44	23.14	31	45.01	53	37.74	52						
Oman	25.95	50	14.44	61	37.45	35	16.37	64	22.81	28	23.30	30	55.83	34	68.93	20	36.09	23	34.73	23	55.02	21
Iraq	25.57	51	28.26	32	22.89	61	16.40	63	5.53	63	9.55	53	43.05	58	39.90	51	24.44	27	25.99	25	23.73	26
Guatemala	25.44	52	22.99	48	27.89	54	21.06	57	13.44	50	8.93	57	45.46	52	50.54	47						
Uzbekistan	25.32	53	18.42	57	32.22	47	22.78	56	6.97	62	14.73	46	53.24	41	63.37	28	25.57	26	18.92	27	19.41	27
Côte D'Ivoire	25.15	54	22.19	52	28.10	53	41.51	35	7.67	61	15.73	41	43.92	56	31.70	59						
Iran	24.92	55	15.23	60	34.62	43	32.94	41	21.64	30	9.69	52	50.22	44	58.60	35	30.02	24	25.43	26	35.62	25
Bangladesh	24.24	56	25.10	37	23.38	58	23.11	55	8.24	60	8.81	58	44.95	54	31.77	58						
Algeria	24.07	57	17.20	58	30.95	50	27.14	51	10.36	55	3.75	64	51.49	43	62.01	31	22.33	28	13.70	28	10.21	28
Kenya	23.60	58	20.38	55	26.81	56	28.12	49	13.65	47	5.57	61	49.29	48	37.46	53						
Pakistan	22.93	59	23.60	44	22.25	63	23.93	54	16.32	41	13.45	47	44.24	55	13.34	64						
Cameroon	21.86	60	22.86	49	20.85	64	19.79	60	9.38	59	6.20	60	40.15	62	28.73	61						
Tanzania	19.30	61	15.70	59	22.89	60	27.85	50	9.71	57	9.02	56	41.29	60	26.58	62						
Nigeria	19.17	62	11.36	62	26.99	55	44.75	30	13.57	49	5.02	62	41.81	59	29.78	60	27.71	25	28.43	24	45.50	24
Ethiopia	17.28	63	11.11	63	23.45	57	20.99	58	16.47	39	9.47	54	38.34	63	31.96	57						
Uganda	15.56	64	8.10	64	23.02	59	30.33	46	11.10	53	8.50	59	40.38	61	24.77	63						

Appendix 3. 2022 and 2021 CCE Index Results

2021 CCE Index Results	Total CCE Index		Performance sub-index		Enablers sub-index		Enablers dimensions										Oil Producers Lens (OPL)					
							Policies and regulation		Technology, knowledge and innovation		Finance and investment		Business environment		System resilliance		Total OPL		Performance sub-index (with OPL)		OPL indicators	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Norway	65.78	1	60.47	1	71.10	6	65.31	9	51.02	10	73.18	2	78.22	1	87.76	2	71.05	2	71.00	1	81.53	4
Netherlands	63.36	2	52.24	2	74.48	2	63.12	10	66.55	7	86.95	1	75.25	8	80.55	7	71.25	1	68.02	2	83.81	3
Germany	61.95	3	47.09	4	76.80	1	83.46	2	77.41	4	64.01	7	77.03	4	82.11	6						
United Kingdom	60.98	4	48.85	3	73.11	3	90.00	1	57.57	8	58.15	12	75.89	7	83.93	5	67.82	3	62.53	3	76.21	5
Switzerland	59.78	5	47.03	5	72.53	4	55.39	15	81.03	1	62.71	10	69.51	15	94.00	1						
France	56.04	6	41.08	9	70.99	7	80.73	3	53.59	9	71.70	4	71.91	9	77.04	11						
Canada	55.48	7	43.29	6	67.68	11	71.74	7	46.98	12	63.73	8	77.39	2	78.56	9	60.58	5	53.48	7	63.68	14
Spain	54.02	8	43.04	8	65.00	12	76.61	5	35.54	18	73.03	3	70.43	10	69.39	19						
United States	53.19	9	38.31	11	68.07	10	61.93	12	69.21	6	52.66	15	76.11	5	80.44	8	61.03	4	53.98	6	69.65	11
Japan	52.60	10	33.96	16	71.24	5	77.68	4	71.71	5	61.46	11	75.92	6	69.44	18						
Australia	50.42	11	37.49	12	63.35	13	71.57	8	45.87	13	53.08	14	77.05	3	69.17	21	57.00	6	50.66	10	63.82	13
Republic of Korea	49.86	12	31.10	21	68.61	9	62.78	11	78.04	2	63.09	9	70.03	11	69.14	22						
Singapore	46.66	13	24.33	37	68.98	8	49.08	25	77.61	3	69.73	5	61.49	19	87.00	3						
Italy	46.54	14	33.58	17	59.51	14	76.00	6	36.74	16	45.10	17	68.29	16	71.41	14						
Chile	44.97	15	39.84	10	50.10	18	54.84	16	16.48	39	65.15	6	58.19	27	55.87	41						
United Arab Emirates	41.86	16	31.07	22	52.64	17	48.65	26	28.69	21	45.36	16	69.86	12	70.66	15	51.29	8	49.94	11	68.80	12
Costa Rica	41.83	17	43.15	7	40.51	31	49.58	22	14.99	43	17.26	40	48.62	45	72.09	13						
Brazil	40.58	18	35.39	13	45.76	23	54.62	17	24.49	25	31.66	25	61.64	18	56.39	40	49.18	10	52.60	8	69.81	10
China	40.02	19	24.41	36	55.63	15	50.02	20	48.98	11	54.01	13	69.68	14	55.46	42	51.95	7	48.28	12	72.15	9
Saudi Arabia	38.03	20	34.16	15	41.91	30	38.95	38	23.23	26	13.10	49	61.66	17	72.60	12	51.11	9	60.31	4	86.46	1
Poland	37.63	21	22.56	45	52.71	16	61.50	13	27.47	23	35.17	22	69.81	13	69.58	16						
Mexico	37.54	22	27.83	27	47.25	20	49.77	21	28.34	22	32.79	24	59.36	22	65.98	26	45.54	13	43.84	16	59.85	16
Colombia	37.00	23	30.84	23	43.17	26	47.77	27	16.92	37	40.19	20	53.88	36	57.07	38						
Viet Nam	36.36	24	25.63	33	47.09	22	45.64	28	35.75	17	42.00	19	59.72	21	52.35	45						
Türkiye	36.16	25	29.57	24	42.74	27	49.29	24	23.17	27	22.67	32	56.69	28	61.86	32						
Malaysia	35.92	26	22.51	46	49.33	19	44.42	30	44.60	14	28.95	26	60.12	20	68.55	24	45.77	12	42.22	17	61.93	15
Thailand	34.95	27	22.75	43	47.15	21	50.19	19	32.86	20	35.91	21	58.91	24	57.89	37						
Jordan	34.76	28	32.13	19	37.39	36	32.01	42	17.24	36	21.40	34	53.53	37	62.79	28						
Argentina	34.66	29	28.87	26	40.45	32	42.44	32	17.65	35	26.59	27	53.50	38	62.04	30	42.15	14	43.86	15	58.85	18
Qatar	33.79	30	25.07	35	42.51	28	20.59	58	33.12	19	15.56	44	58.49	26	84.79	4	48.68	11	54.85	5	84.63	2
Ecuador	33.62	31	34.46	14	32.79	46	45.21	29	12.92	51	4.85	63	44.53	52	56.43	39						
Philippines	33.56	32	29.04	25	38.09	33	29.53	46	38.90	15	18.22	38	52.40	39	51.37	46						
Russian Federation	32.38	33	19.16	53	45.60	24	58.39	14	22.08	29	21.58	33	58.96	23	66.99	25	39.74	18	33.88	23	48.60	23
Peru	32.06	34	32.24	18	31.88	48	29.20	47	10.14	56	15.91	43	51.39	42	52.77	44						
Bahrain	31.67	35	25.67	32	37.68	34	26.90	52	14.99	44	18.40	37	58.51	25	69.58	17						
Indonesia	30.79	36	26.80	30	34.78	41	29.78	45	21.58	31	19.27	35	55.30	31	47.96	49	38.01	19	41.24	19	55.69	19
Egypt	30.67	37	27.81	28	33.52	45	30.50	43	16.91	38	14.16	47	47.39	48	58.66	36	37.47	20	41.41	18	55.01	20
South Africa	30.58	38	19.20	52	41.96	29	49.55	23	19.02	33	42.44	18	54.50	32	44.27	50						
Dominican Republic	30.01	39	25.15	34	34.87	40	40.23	35	13.69	48	13.83	48	46.05	50	60.56	34						
Kazakhstan	29.83	40	14.86	60	44.80	25	50.93	18	12.77	52	34.60	23	56.37	29	69.34	20	39.82	17	34.84	22	54.82	21
Azerbaijan	29.38	41	22.68	44	36.08	39	24.50	53	14.72	46	23.88	30	55.62	30	61.67	33	42.07	15	48.07	13	73.46	7
Tunisia	28.75	42	22.76	42	34.74	42	34.67	40	18.94	34	9.30	57	48.45	47	62.32	29						
Morocco	28.53	43	20.28	51	36.79	38	40.05	36	15.37	42	23.39	31	52.20	40	52.93	43						
Kuwait	28.02	44	18.66	54	37.38	37	17.47	61	19.57	32	16.82	41	54.49	33	78.55	10	41.80	16	46.22	14	73.77	6
Sri Lanka	27.82	45	23.48	41	32.16	47	39.41	37	9.48	58	14.29	46	48.61	46	48.99	48						
India	27.78	46	21.33	48	34.23	44	41.93	33	24.49	24	15.26	45	54.40	34	35.09	54	37.25	22	40.27	20	59.20	17
Angola	27.12	47	31.57	20	22.67	61	15.01	64	3.43	64	26.24	28	31.54	64	37.15	53	37.46	21	52.24	9	72.92	8
Lebanon	26.76	48	24.16	38	29.36	51	29.07	48	14.91	45	19.10	36	45.62	51	38.08	52						
Oman	26.62	49	15.80	59	37.44	35	16.37	63	22.37	28	25.53	29	54.34	35	68.58	23	36.24	23	35.04	21	54.28	22
Ghana	26.14	50	24.05	39	28.22	53	38.25	39	10.98	54	17.41	39	40.93	58	33.54	56						
Iran	25.53	51	16.61	58	34.44	43	32.94	41	21.62	30	9.67	55	48.86	44	59.11	35	30.72	24	27.01	25	37.40	25
Iraq	25.51	52	27.77	29	23.26	58	16.40	62	4.88	63	10.12	53	41.13	57	43.77	51	24.74	27	26.23	26	24.69	26
Côte D'Ivoire	25.50	53	22.36	47	28.64	52	41.51	34	7.67	61	16.77	42	42.25	56	34.98	55						
Uzbekistan	25.05	54	18.45	55	31.64	49	22.78	55	6.91	62	12.58	50	52.16	41	63.77	27	25.33	26	19.03	27	19.60	27
Algeria	23.82	55	17.04	57	30.61	50	27.14	51	10.39	55	3.56	64	49.99	43	62.00	31	22.42	28	14.23	28	11.42	28
Pakistan	23.72	56	26.05	31	21.40	63	21.93	56	16.31	41	12.56	51	42.41	55	13.79	64						
Bangladesh	23.60	57	23.90	40	23.31	57	23.11	54	8.94	60	9.31	56	43.08	54	32.09	57						
Kenya	23.31	58	20.29	50	26.33	55	28.12	49	13.70	47	10.61	52	47.29	49	31.93	58						
Guatemala	22.48	59	18.18	56	26.78	54	19.06	60	13.44	50	7.44	60	43.97	53	49.98	47						
Cameroon	20.71	60	20.61	49	20.80	64	19.79	59	9.39	59	6.44	61	38.54	62	29.83	60						
Nigeria	19.05	61	11.99	62	26.11	56	42.75	31	13.57	49	4.87	62	40.38	59	29.01	61	28.13	25	30.14	24	48.28	24
Tanzania	18.52	62	14.80	61	22.24	62	27.84	50	9.70	57	8.49	59	39.35	61	25.81	62						
Ethiopia	17.13	63	11.11	63	23.16	59	20.99	57	16.47	40	9.75	54	37.14	63	31.47	59						
Uganda	15.46	64	8.06	64	22.86	60	30.33	44	11.10	53	8.61	58	39.58	60	24.70	63						

Endnotes

[1] There are different ways of grouping the various 'CCE activities' under each R. For other taxonomies, see Luomi et al. (2021), Table 2, and Luomi, Yilmaz, and Alshehri (2021b).

[2] The detailed country selection criteria are presented in Appendix 1.

[3] The CCE Index adopts a simplified version of the official U.N. English spelling of country names. This is applied across the figures in this discussion paper, as well as in the CCE Index portal. The spelling is based on the list of U.N. Member States: https://www.un.org/en/about-us/member-states (accessed September 25, 2022).

[4] From 2022 onward, the CCE Performance sub-index excludes firewood and waste from its renewable energy indicator. A number of lower-income countries, particularly in Africa, generally have higher rates of firewood in their energy mix, which are not counted from this edition onward. Similarly, this edition has introduced a second component to the natural sinks indicator to reward countries that have larger forest-to-total-land-area ratios. Please see Appendix 1 for the rationales behind these changes.

[5] This is likely to reflect the fact that all its seven indicators come from other composite indicators. Composite indicators generally seem to tend to give countries fewer aggregate scores of zero or close to zero – similar to the CCE Index.

[6] For the 2022 CCE Index, 30 major oil and gas producers were initially included in the country selection, but Libya and Turkmenistan did not qualify for inclusion due to insufficient data availability. For inclusion criteria, see Appendix 1.

[7] These year-on-year changes translated differently into changes in country ranks. In most cases, countries either retained their rank or moved up or down by between one to three ranks. The only exceptions were Guatemala (which moved up from rank 59 to 52), Kazakhstan (up from 40 to 27), Iran (down from 51 to 55) and Bahrain (down from 35 to 39).

[8] This sub-index saw a lot of movement in country ranks. Most countries fluctuated within a range of five. The exceptions to this were Kazakhstan (which moved up from 60 to 31), Kuwait (up from 54 to 43), Malaysia (up from 46 to 35), Guatemala (up from 56 to 48), Australia (up from 12 to 5), Russia (up from 53 to 47), the Republic of Korea (up from 21 to 15), Pakistan (down from 31 to 44), Lebanon (down from 38 to 50), Thailand (down from 43 to 51) and Bahrain (down from 32 to 38).

[9] Detailed information about the years of data used for each indicator for both the 2021 and 2022 editions is available via the CCE Index web portal and the 2022 CCE Index codebook (available via the web portal).

[10] On CCE Enablers, all but one country saw their ranks remain the same or increase or decrease by one or two ranks between 2021 and 2022. Iraq's rank fell by three (from 58 to 61).

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Dr. Luomi is a Fellow II in KAPSARC's Climate and Sustainability program. A policy-oriented social scientist, she has been studying climate change, energy transitions and sustainable development policy in the Gulf and globally for 15 years. At KAPSARC, she leads the Carbon Markets and Paris Agreement Article 6, and the Circular Carbon Economy Index projects. She has previously worked for other leading energy, sustainable development and foreign policy research institutions, including the Oxford Institute for Energy Studies, the International Institute for Sustainable Development (Earth Negotiations Bulletin), Georgetown University, the Finnish Institute of International Affairs, and the Emirates Diplomatic Academy.

Dr. Luomi holds a master's degree in political science and international politics from the University of Helsinki and a Ph.D. in Middle Eastern studies from Durham University. In addition to a broad research publications portfolio, she has substantial experience in executive training, presentations, policy advisory, and reporting services for multilateral environmental negotiations.

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Prior to joining KAPSARC, Dr. Yilmaz worked as an economist in the Structural Economic Research Department of the Central Bank of the Republic of Turkey, where he was involved in researching and designing policies for the private and banking sectors. He also worked as a consultant for the World Bank and has contributed to other advisory projects for different governments and international institutions. As an academic, he taught several courses in economics and econometrics at ADA University and the University of Calgary.

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Dr. Alshehri also acts as an advisor to the broader energy ecosystem in Saudi Arabia, particularly in the areas of clean energy transitions, sustainability, and carbon emissions management. He is also a member of the Technology and Economic Assessment Panel, United Nations Environment Programme (UNEP). He previously worked as a lecturer in Australia and has entrepreneurial and industrial experience working on award-winning projects such as the Burj Khalifah Building Management System.

About the Project

KAPSARC's Circular Carbon Economy (CCE) Index project seeks to expand and add rigor to the conceptual basis of the CCE concept, as well as its practical operationalization, by developing a robust quantitative framework to measure countries' performance and their progress toward CCEs. The resulting CCE Index is a composite indicator that measures various dimensions of the CCE in a national context, across countries. Its main foci are current performance and enabling factors for future progress.

The first edition of the CCE Index, published in November 2021, covered 30 countries. From the 2022 edition onward, the index covers 64 major economies and oil and gas-producing countries. The index is disseminated through various research outputs, including KAPSARC discussion papers and commentaries, which present the index results and analyze them in depth, as well as KAPSARC methodology papers, conferences, workshops and other events, and an online platform, located at https://cceindex.kapsarc.org. The index is updated annually, with the 2022 edition launched in November 2022.

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