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King Abdullah Petroleum Studies and Research Center

The Gulf Cooperation Council and the Circular Carbon Economy: Progress and Potential

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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Introduction

Over the past year, all six Gulf Cooperation Council (GCC) countries have updated their medium-term greenhouse gas (GHG) emission targets by submitting revised nationally determined contributions (NDCs) under the Paris Agreement. Bahrain, Saudi Arabia, the United Arab Emirates (UAE), and Saudi Aramco have also announced net-zero emission targets. Work is now beginning to develop more detailed roadmaps and implementation plans, some elements of which are already laid out in the updated NDCs.

As the region embarks on this ambitious journey, its energy stakeholders will need to make key choices about the technologies they wish to support and invest in. In parallel, they will need to foster the right kind of enabling conditions that will facilitate the transitions to carbon neutrality. These include more detailed policies and regulatory frameworks, strengthened financial and logistical infrastructures, robust innovation support, and attractive business environments, among others.

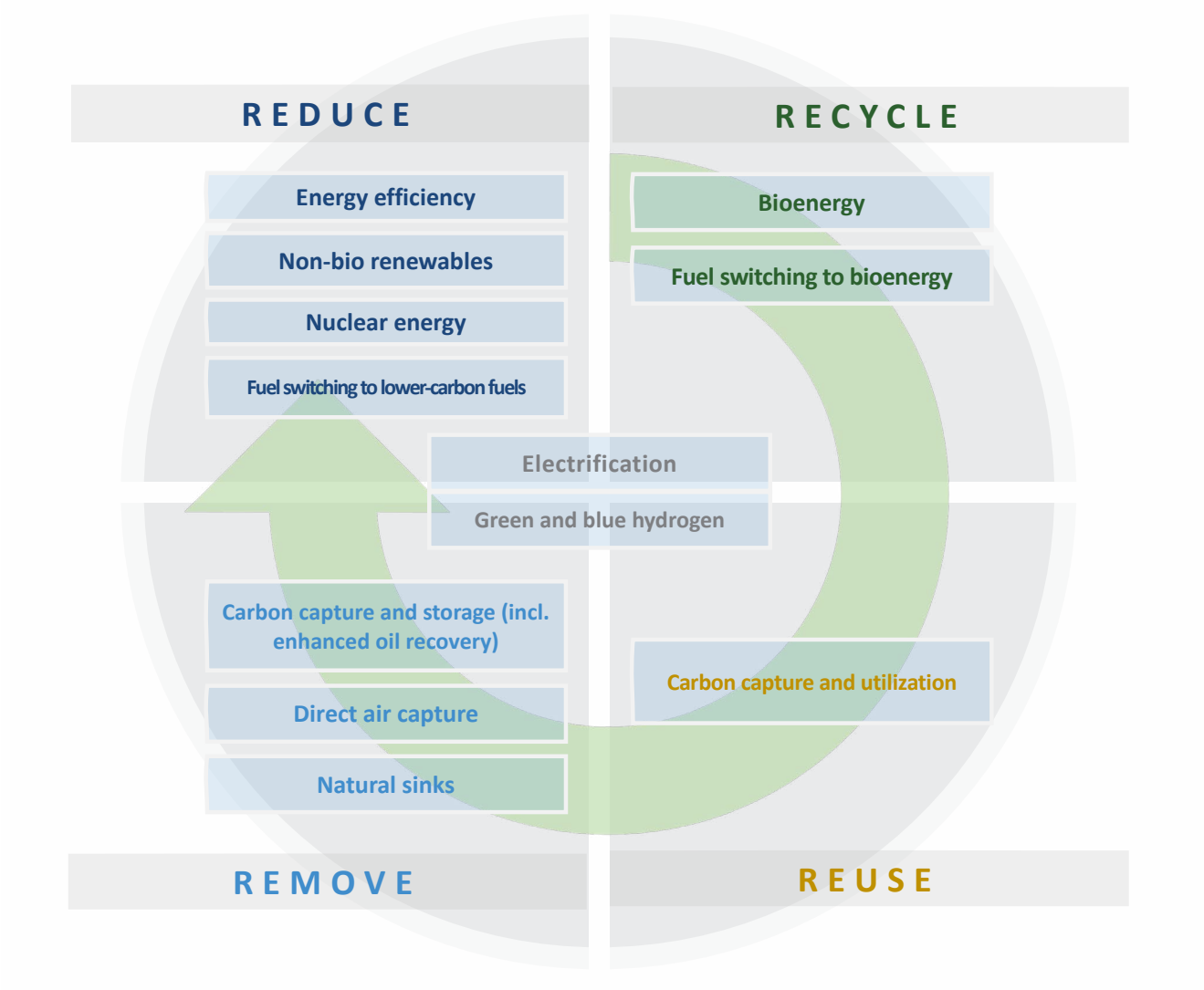
The circular carbon economy (CCE) is a concept developed jointly by Saudi and international researchers and energy sector actors. Its ultimate goal is full carbon circularity or, in other words, carbon neutrality or net-zero carbon dioxide (CO_2) emissions. The concept aims to provide a holistic, technology-agnostic, and cost-effective framework for assessing climate change mitigation options and pathways at a global, national or organizational level.

The CCE builds on the three 'Rs' of the circular economy concept – reduce, recycle and reuse – but adds a fourth R for remove, and focuses on energy and emissions flows instead of materials and products. The CCE approach embraces all mitigation technologies (e.g., renewable energy and carbon capture, utilization and storage [CCUS]) and activities (e.g., energy efficiency, fuel switching, and natural carbon sinks). In simple terms, the CCE draws attention to the need to focus on preventing CO_2 emissions and other GHGs from reaching the atmosphere, instead of focusing on specifying a list of technologies (see, e.g., McDonough [2016]; Williams [2019]; Luomi et al. [2021]). An illustration of the CCE concept is provided in Figure 1.

Using the CCE concept can help raise the level of mitigation ambition globally because it broadens the scope of available technology options. First, the framework can help any country assess a wider variety of mitigation options side by side, conduct cost comparisons, assess different technologies' potential, and identify where support needs to be scaled up to reach this potential. Second, the CCE's technology-agnostic approach can help with achieving a buy-in from many industries, sectors, and countries that have large hydrocarbon endowments and/or limited cost-effective options to decarbonize without using fossil fuels. Despite their significant potential to contribute emission reductions, for example through large-scale CCUS deployment, these actors are often seen mainly as incumbents in the current energy transition discussion discourse, which has created barriers for their engagement.

While the CCE concept is sometimes seen as putting exclusive emphasis on CCUS-related applications, it in fact considers these technologies as a part of a broader mix of mitigation solutions that each country will apply according to its own strengths and priorities. The end goal of the CCE is an economy in which carbon emissions are either avoided in the first place, removed permanently, or circulate through it while generating value, and ultimately resulting in net-zero emissions.

Figure 1. The circular carbon economy.



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

This KAPSARC Discussion Paper starts from the premise that although each country will have its own, unique pathway to net-zero and CCEs, the GCC countries share a number of structural and other similarities, which create opportunities for both sharing lessons and cooperating on the road to net-zero emissions. At the same time, there are marked differences among the GCC countries in how they are positioned on the road to net-zero and CCEs, and understanding these can help energy and climate stakeholders design better policies.

This Discussion Paper presents a comparative evaluation of where the GCC countries stand today on the road to CCEs and their potential to move toward carbon neutrality by mid-century. The analysis is based on KAPSARC's recently launched CCE Index, which benchmarks 30 major economies and oil-producing countries on 47 quantitative indicators (Luomi, Yilmaz, and Alshehri 2021a, 2021b).

After summarizing the 2021 CCE Index results and a brief overview of the GCC countries' standing in the overall Index, the Discussion Paper zooms in on three questions:

- How are the GCC countries performing on the CCE at present, based on the CCE Performance sub-index?
- How are the GCC countries positioned to transition toward CCEs going forward, based on the CCE Enablers sub-index?
- How are the GCC countries' oil and gas sectors and related industries performing, and how are they positioned to make progress on CCEs, based on the CCE Oil Producers Lens indicators?

The paper ends by using the CCE framework to analyze the strengths, weaknesses, and gaps in the GCC countries' internationally communicated climate plans. It also compares these plans with the GCC countries' CCE Performance scores to gauge where activities could be expected to be scaled up in the near term.

The paper finds that, although as a group the GCC countries outperform their non-OECD peers and neighbors in the Middle East and Africa region in most areas measured by the CCE Index, they should undertake further efforts if they wish to improve their position in the global CCE transition. However, among the GCC countries, there are several individual bright spots.

2021 CCE Index: High-level Overview of the Scores

The CCE Index provides a composite score for comparing countries' standings vis-à-vis CCEs on two dimensions: current performance and future potential. The total index score consequently comprises two parts of equal weights: the CCE Performance score measures the diversity and depth of countries' engagement with eight different CCE activities: energy efficiency, renewable energy, electrification, nuclear energy, fuel switching, natural sinks, CCUS, and green hydrogen. It consists of eight quantitative indicators. The CCE Enablers score gauges how well countries are positioned to make progress toward CCEs going forward. The Enablers score comprises five parts of equal weight: policies and regulation; technology, knowledge and innovation; finance and investment; business environment and energy infrastructure; and socioeconomic context. The Enablers sub-index has a total of 29 different indicators, classified under these five areas.[1]

Given the aim of this paper, to identify both similarities and differences between the GCC countries, the analysis below examines the GCC countries both as a group, comparing them with other peer country groups, and each GCC country individually, comparing them with the GCC countries' average and each other. Since the 2021 edition of the CCE Index only includes the G20 member countries and top-20 global oil-producing countries (a total of 30 countries), Bahrain is not included in the index. Throughout the paper, therefore, "GCC average" always refers to the average score of the five other GCC member countries.[2]

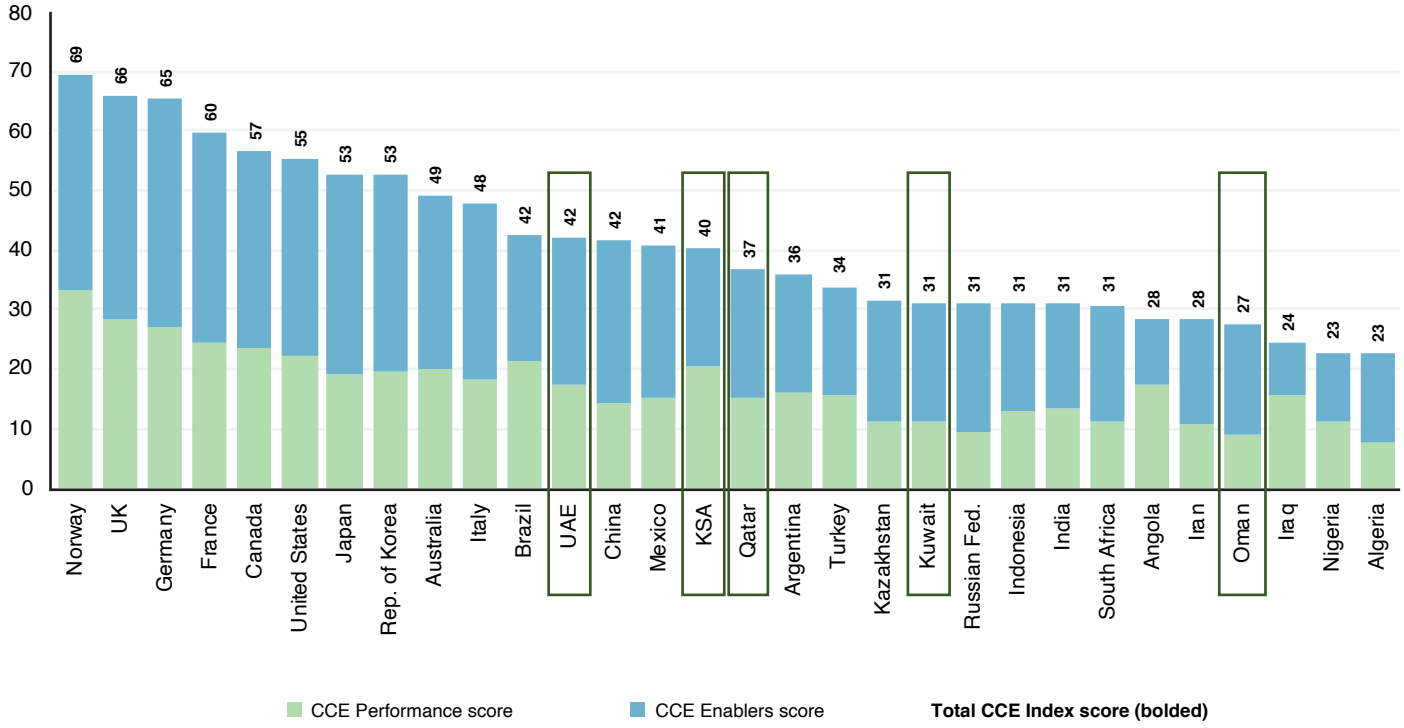
Figure 2 shows the 2021 CCE Index total scores, with a breakdown of the relative contributions of the Performance and Enablers sub-indices. Among the 30 countries included in this edition, the GCC countries' ranks range from the twelfth to the twenty-seventh, with the UAE ranking the highest and Oman the lowest.

As a group, the GCC countries, with an average total CCE Index score of 35, rank below the average score of the 30 countries included in the index (41), as well as the average scores of the 15 high-income countries (50) and 19 major oil producers (39). As a group, on average they score higher than the 18 non-OECD countries and the 11 Middle Eastern and African countries included in the index. Similarly, on both the CCE Performance and Enablers sub-indices, the GCC countries as a group score lower than the 30-country, high-income, and oil producers' averages and higher than the non-OECD and Middle East and Africa averages (see Figure 3, Panel A).

Individually, as displayed in Figure 3, Panel B, the UAE (42), Saudi Arabia (KSA, 40), and Qatar (37) have total CCE Index scores above the GCC group average (35), and Kuwait (31) and Oman (27) score below this average. The five countries' CCE Performance and CCE Enablers scores show a similar pattern, with two exceptions: Saudi Arabia has a higher Performance score (41) than the UAE (35), while its Enablers score (40) ranks just below the GCC average (42).

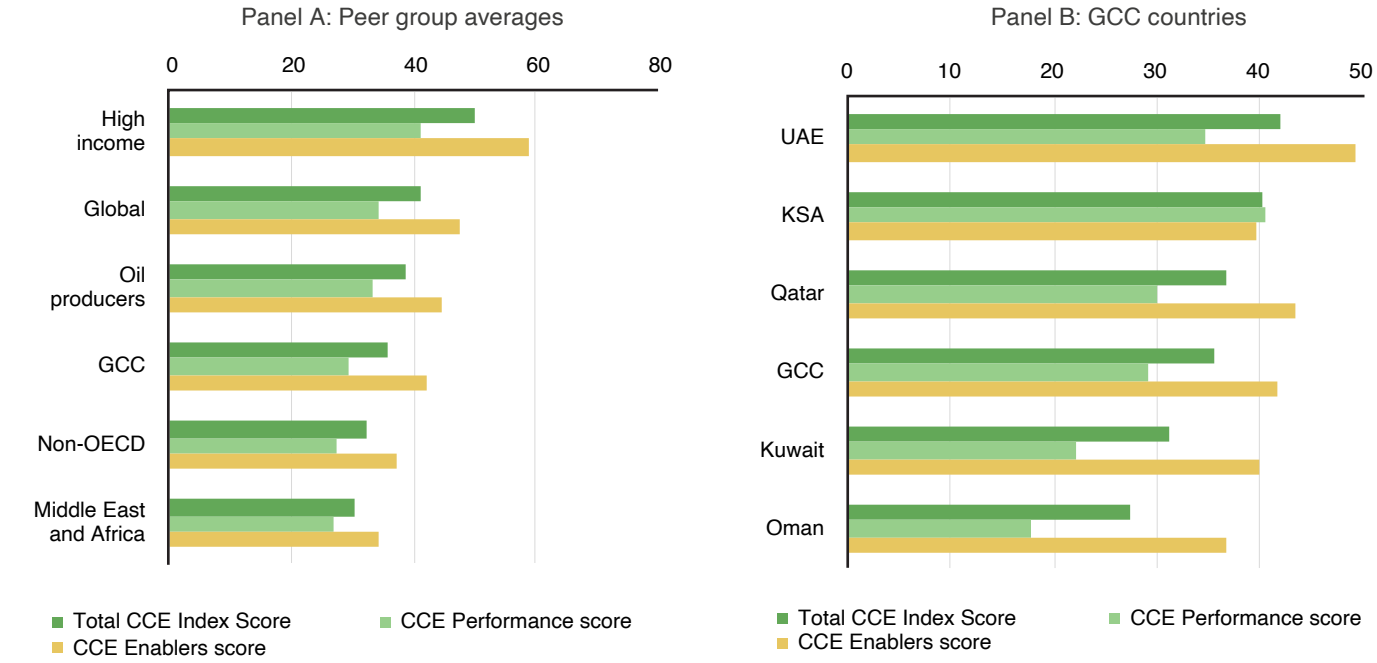
Measured by the variation between the five GCC countries' scores, as expected, the GCC is a more homogeneous group than the broader 30-country group. Among the 30 countries, there is a 46-point difference in the total CCE Index scores between the top and bottom performers, whereas this difference reduces to 15 points between the GCC countries. At the same time, as shown by the high-level overview of the CCE Index total and sub-index scores above, there are major differences among the five GCC countries. The following sections unpack these differences — and similarities — by deconstructing the two sub-indices.

Figure 2. The GCC countries in the 2021 CCE Index – Performance and Enablers sub-indices.



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

Figure 3. The GCC countries in the 2021 CCE Index – group and individual comparisons.



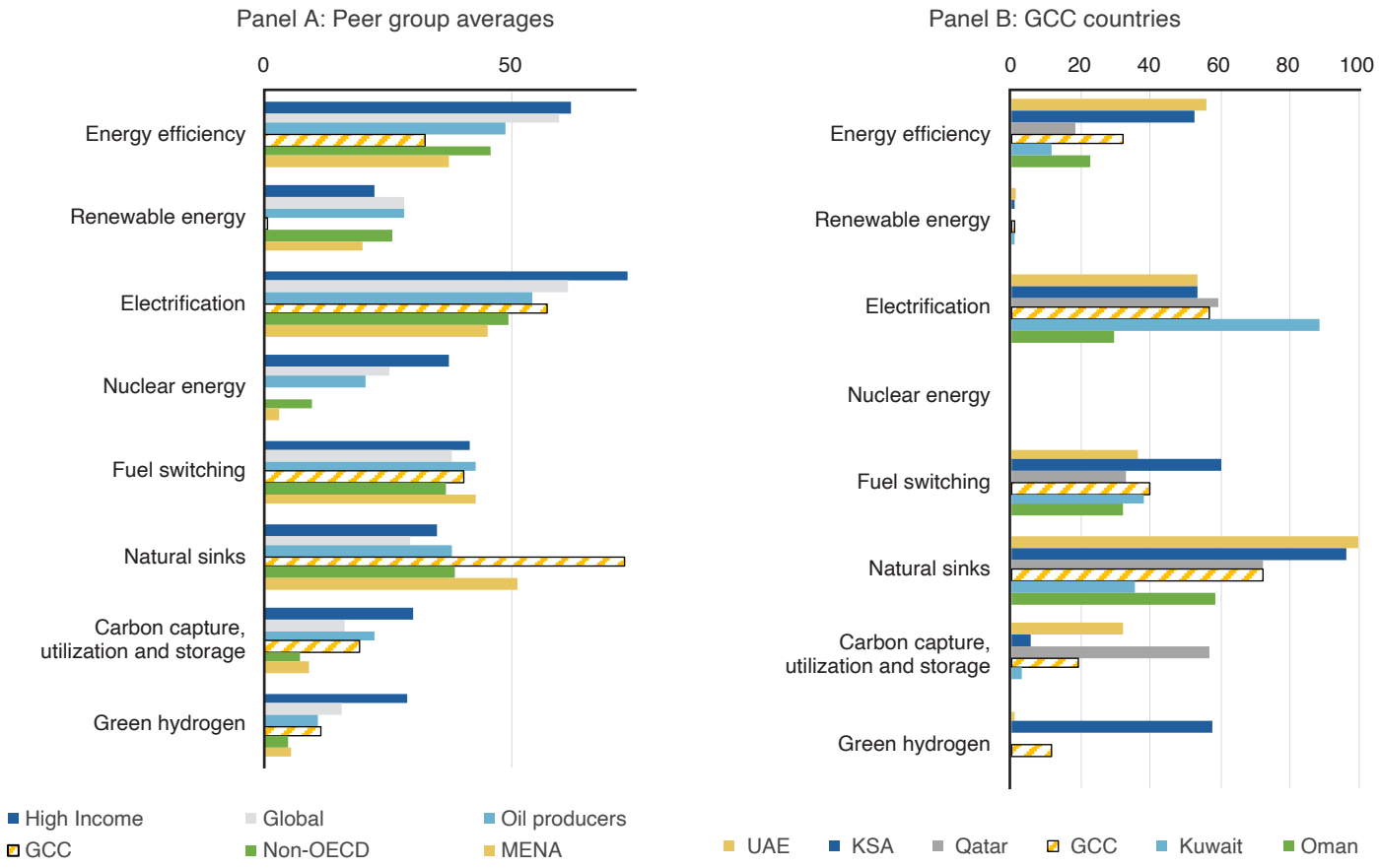
Source: Authors.

CCE Performance: The Diversity and Depth of Current Activities

The CCE Performance sub-index measures how countries are engaging with eight CCE activities and technologies, which cover the major climate change mitigation options presently available worldwide.[3] The indicators draw from harmonized international datasets and are designed to serve as representative proxies for each activity. Energy efficiency, for example, is measured by the energy intensity of an economy, and renewable energy by the share of renewables in the energy mix.[4] Because the CCE Index gives each CCE activity an equal weight, countries that engage in a broader variety of activities score better.[5]

Figure 4 shows how the GCC countries, as a group and individually, are faring on each of the eight CCE activities. Figure 4, Panel A illustrates how the GCC countries scores on average compare with the 30 countries' average and four peer groups. The GCC as a group scores higher than all others in only one area, natural sinks. This indicator, taken from Yale University's Environmental Performance Index, measures how well countries are preserving their *existing* ecosystems, primarily forests. Countries are therefore rewarded for what they preserve, irrespective of the size of these natural carbon sinks.

Figure 4. The GCC countries' CCE Performance scores compared.



Source: Authors.
Note: GCC does not include Bahrain.

There are two areas where the GCC countries, as a group, perform significantly worse than other groups measured: renewable energy and nuclear energy (see Figure 4, Panel A). All countries score either zero or close to zero on both activities. While not all countries can be expected to deploy nuclear energy,[6] renewable energy resources are abundant in the GCC region and technologies are also cost-effective there. The GCC countries' hydrocarbon endowments are the obvious explanation for the low levels of other energy sources in the mix. However, as will be discussed further below, significant scaling up is expected in the coming years in some GCC countries, based on their current renewable energy targets.

In the other areas, the GCC averages do not stand out in the group comparisons, but there are high variations among the individual GCC countries (see Figure 4, Panel B). Fuel switching measures the total share of coal and oil — the most carbon intense fossil fuels — in the total electricity mix. It considers a country's starting point (the share of these sources in 2014) and how rapidly a country has moved away from them over the past five years (2014–2019). Here, Saudi Arabia ranks significantly higher than its GCC peers, owing to a 21 percentage point drop in the share of oil in its electricity mix (from 62% in 2014 to 41% in 2019).

There is a wide variation in the GCC countries' electrification scores (Figure 4, Panel B). This indicator measures the share of electricity in the country's total energy mix. Among other things, it can be used to indicate how well countries are positioned to electrify their economies (in the CCE Index it is also used as a control for the share of commercial renewables). However, high shares of electricity in the energy mix can also be a sign of other things, such as an absence of heat-intensive industries or inefficiencies on the demand side.

In the case of Kuwait, high per capita electricity demand (16.3 megawatt hours [MWh] per capita in 2019) indicates a more inefficient use of energy than in other GCC countries. Oman's electricity per capita consumption, in contrast, was only 7.0 MWh in 2019 (IEA 2021a).

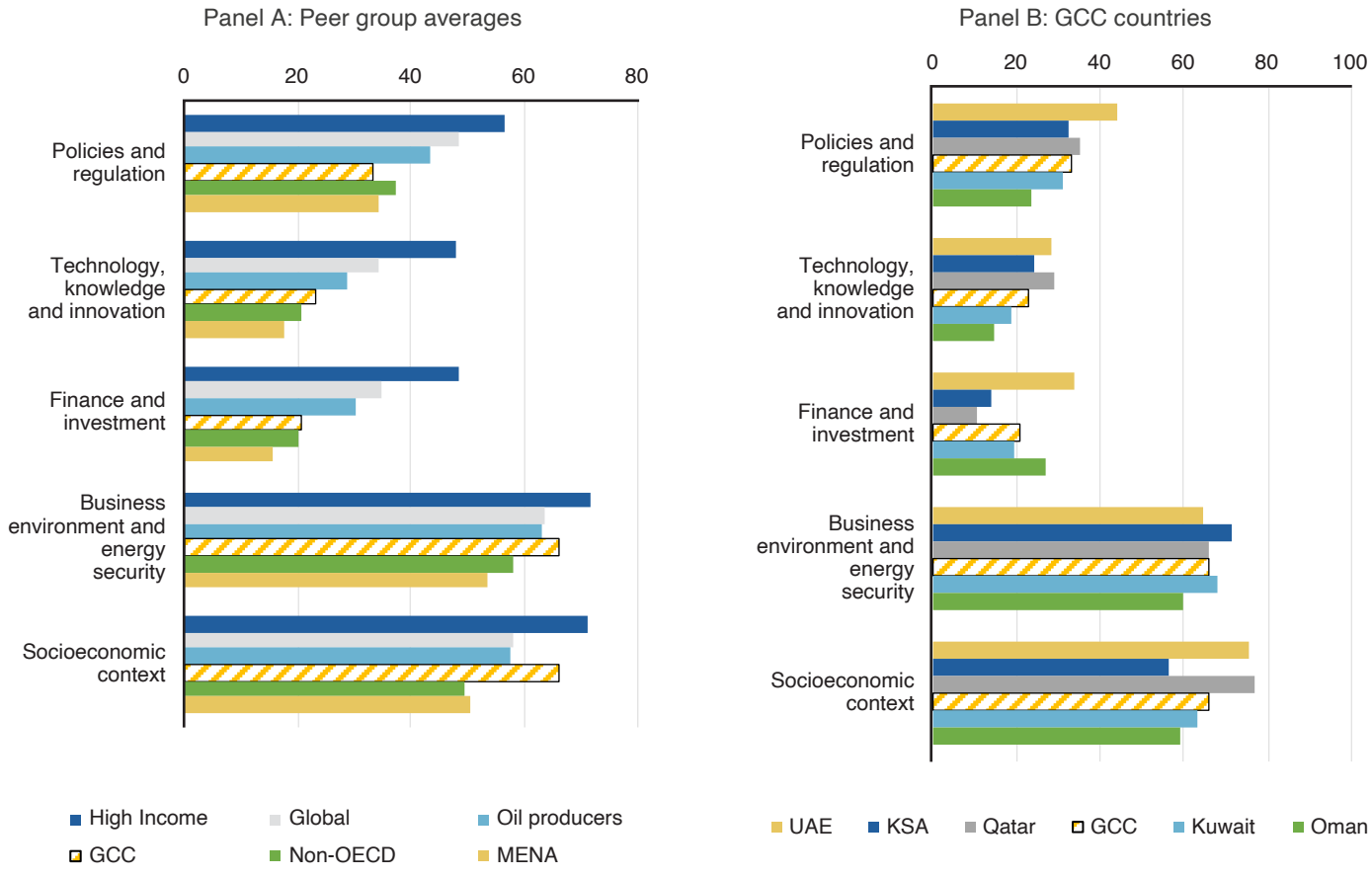
Given the presently low levels of deployment, the CCUS and green hydrogen[7] indicators also factor in projects that are in the pipeline (e.g., in planning or development, and financed or under construction). On these indicators, two countries — Oman and Qatar — had no registered projects as of September 2021. Capacity data for both indicators is divided by the country's gross domestic product (GDP) to consider its economy size. On green hydrogen, Saudi Arabia's Neom project, which in the BloombergNEF's (BNEF's) database features a 2-gigawatt capacity, grants the country a high score. On CCUS, Qatar achieves a high score from an enhanced oil recovery (EOR) project and methanol production facility, with a total capacity of 2.28 million tonnes of carbon dioxide ($MtCO_2$) per year. The UAE similarly gets a high score from two EOR projects and a urea production facility with a total capacity of 3.25 $MtCO_2$/year.

CCE Enablers: Potential to Transition to Net-zero and CCEs

The 2021 CCE Index results indicate larger gaps among countries in three of the five areas of the Enablers sub-index, which can unlock countries' potential to accelerate CCE transitions. These are policies and regulation; technology, knowledge, and innovation; and finance and investment (see Figure 5). The GCC region's average in these areas is lower than that of the high-income, 30-country and oil producers' groups (Figure 5, Panel A). Compared with the non-OECD and Middle East and Africa group averages, the GCC group average is either slightly higher or equivalent. For instance, the GCC group's average finance and investment score is 21, while that number is 48 for the high-income group, 35 for the 30 countries, and 30 for the oil producers. The average scores for the non-OECD and the Middle East and Africa are 20 and 16, respectively.

As displayed in Figure 5, Panel B, the GCC countries appear to score similarly on the business environment and energy security, and socioeconomic context dimensions. While there are minor differences among them in terms of their scores on socioeconomic context, their scores for the business environment and energy infrastructure dimension are strikingly similar.

Figure 5. The GCC countries' CCE Enablers scores compared.



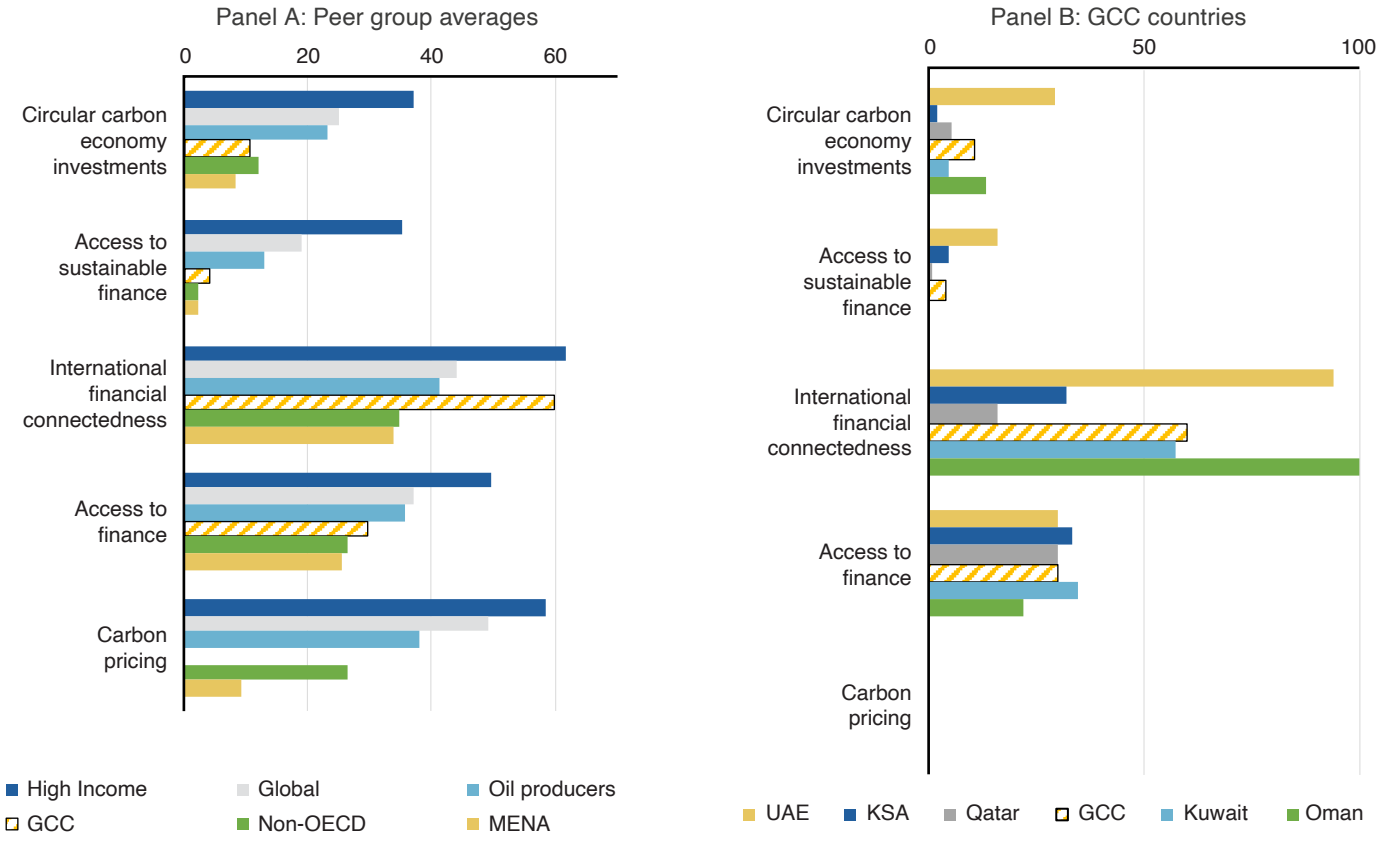
Source: Authors.
Note: GCC does not include Bahrain.

Significant gaps exist in the other three enabling dimensions across the GCC countries (Figure 5, Panel B). More specifically, the UAE ranks the highest in the region in the policies and regulation dimension; Saudi Arabia, Qatar, and Kuwait lie around the GCC average; and Oman scores below the group average. The technology, knowledge and innovation dimension has a similar distribution, but the group average and country-level scores here are lower than in the policy and regulation dimension.

The largest gaps across the GCC countries exist in the finance and investment dimension (Figure 5, Panel B). The UAE leads this dimension, while Oman records the second-highest score. Kuwait's performance is around the GCC average, while Saudi Arabia and Qatar are below the average.

Considering the large differences across the countries, the finance and investment dimension deserves a closer look, which is provided in Figure 6. The figure presents the key metrics covered under this dimension, which measure CCE investments (in renewable energy, hydrogen, carbon capture and storage, energy storage, and electrified heat and transportation); access to sustainable finance (sustainable debt); international financial connectedness (foreign direct investment, net inflows and outflows); access to conventional finance (access to credit, size of stock and bond markets); and carbon pricing (emissions trading scheme or carbon tax). Figure 6, Panel A presents a comparison with the peer group benchmarks, and Figure 6, Panel B shows the similarities and differences across the GCC economies.

Figure 6. The GCC countries' CCE Enablers scores compared: Finance and Investment.



Source: Authors.
Note: GCC does not include Bahrain.

The GCC regional average in international financial connectedness is considerably higher than the other groups (Figure 6, Panel A). It is well above the 30 countries' and oil producers' averages and around the high-income country group average level. In terms of access to finance, the GCC region is slightly below the high-income, 30 countries', and oil producers' averages but stands higher than the other two country groups. However, the region's average scores in the three-remaining metrics — CCE investment, access to sustainable finance, and carbon pricing — are below the respective benchmarks.

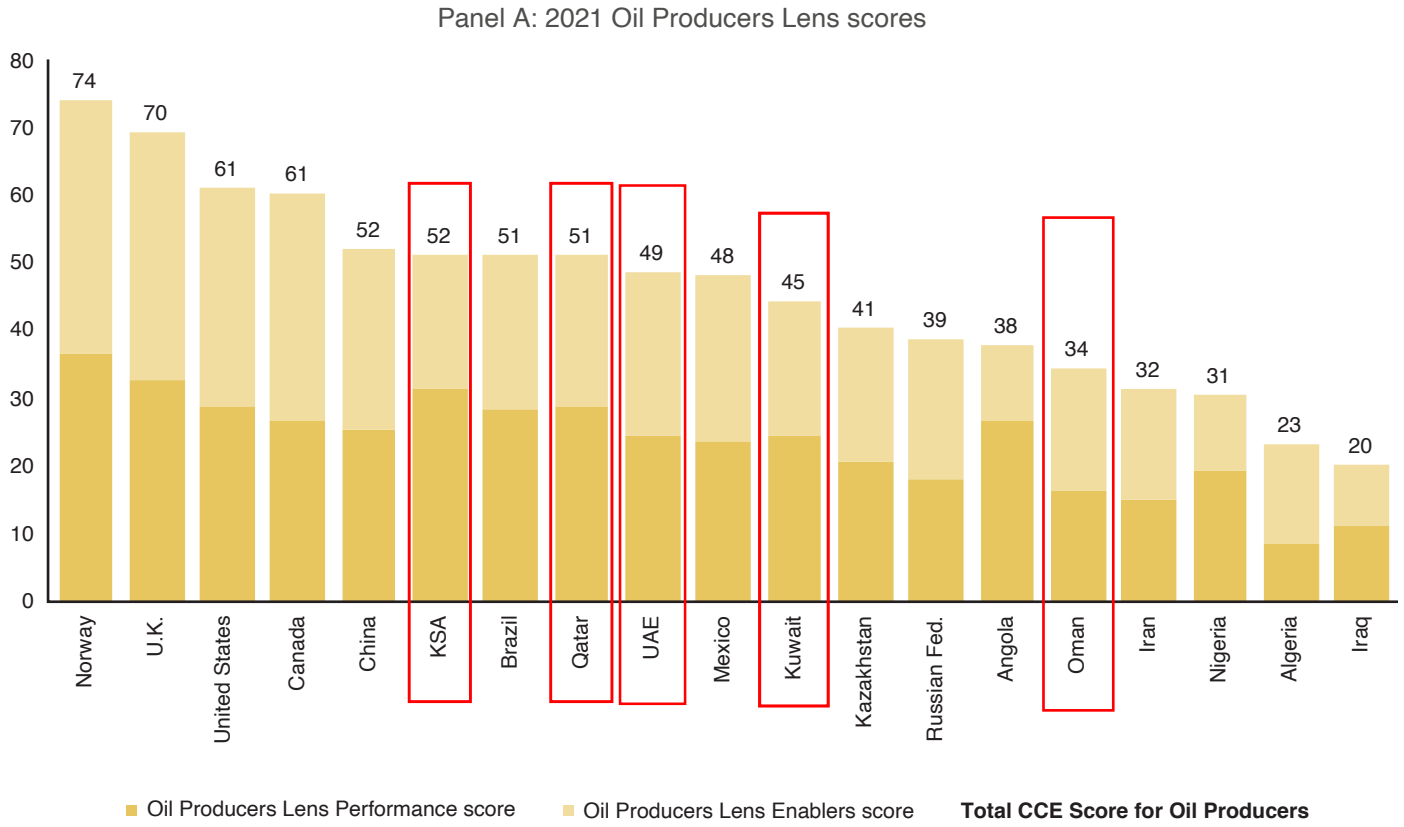
Across the GCC economies (Figure 6, Panel B), the UAE ranks the highest in CCE investments and access to sustainable finance. Notably, the UAE's and other GCC countries' CCE investment scores come exclusively from investments in renewables in 2018–2020 (the period measured by the indicator), as the dataset from BNEF used for this indicator does not include data for CCS, hydrogen or other CCE technologies for these countries. The vast majority of the UAE's sustainable access score is generated by green and sustainability-linked loans that were issued by the financial and energy sectors in the past three years through September 2021 (the period measured by the indicator), but some green bond issuance has also taken place in the country over this period.

The other GCC economies also scaled up their CCE investments during this period; Oman stood around the GCC average and others remained below. Similarly, they also leveraged some sustainable finance in the period between 2019 and 2021, although the general flows were quite low compared with the peer group benchmarks. Here, Saudi Arabia recorded around the GCC average, while others stood significantly below. Finally, none of the GCC economies currently engages in subnational or national-level carbon pricing activities, which gives them a zero score on this indicator.

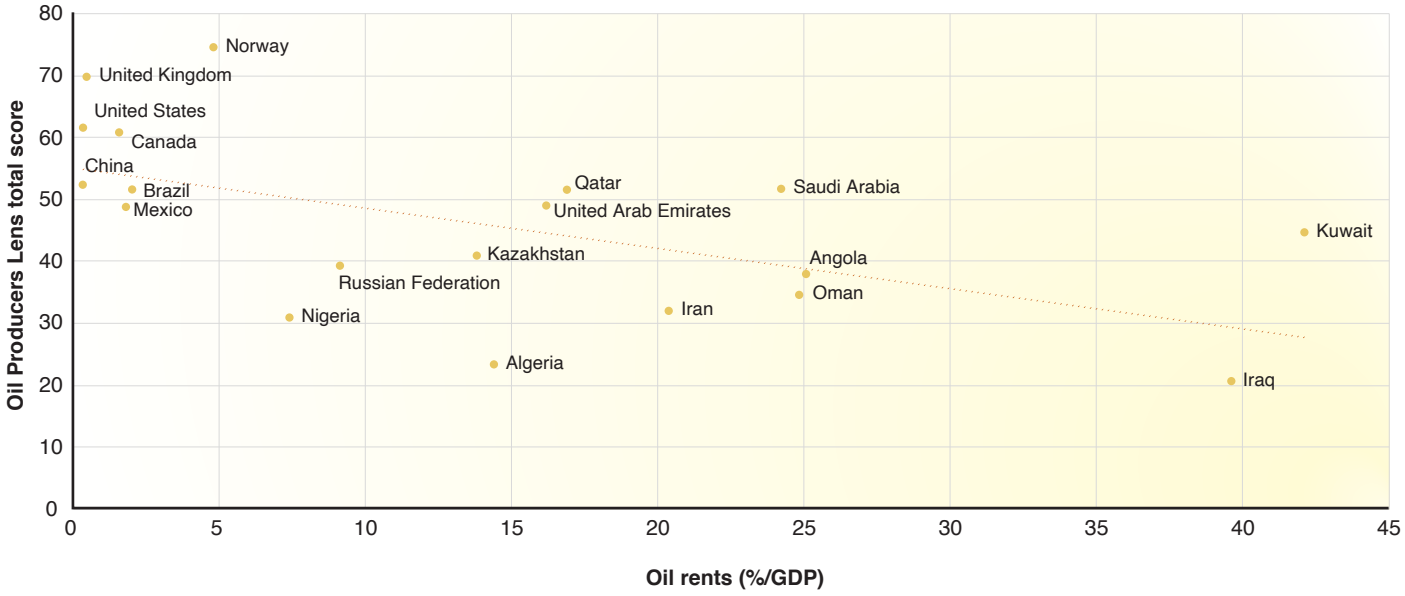
Oil Producers Lens: Gauging Industry's CCE Performance and Potential

The 2021 CCE Index includes 19 major global oil-producing countries. It contains an additional set of indicators aimed at enabling further comparisons among these countries, which face both challenges and opportunities unique to this group that stem from the size of their hydrocarbon industries. The Oil Producers Lens score is calculated by adding five indicators to the Performance sub-index and five indicators to the Enablers sub-index. The score aggregation logic is shown in Appendix 1. The 2021 ranking for the Oil Producers Lens is shown in Figure 7, Panel A. There are some changes in rank compared with those of the same 19 countries in the 2021 total CCE Index. For the GCC countries, the major changes are Saudi Arabia's higher ranking — it ranks sixth on the Oil Producers Lens, compared with ninth among the 19 oil producers included in the total CCE Index score — and the UAE's lower ranking — ninth compared with sixth in the total CCE Index.

Figure 7. The GCC countries in the 2021 Oil Producers Lens ranking and oil rent levels.



Panel B: 2021 Oil Producers Lens scores and oil rent reliance (% of GDP)

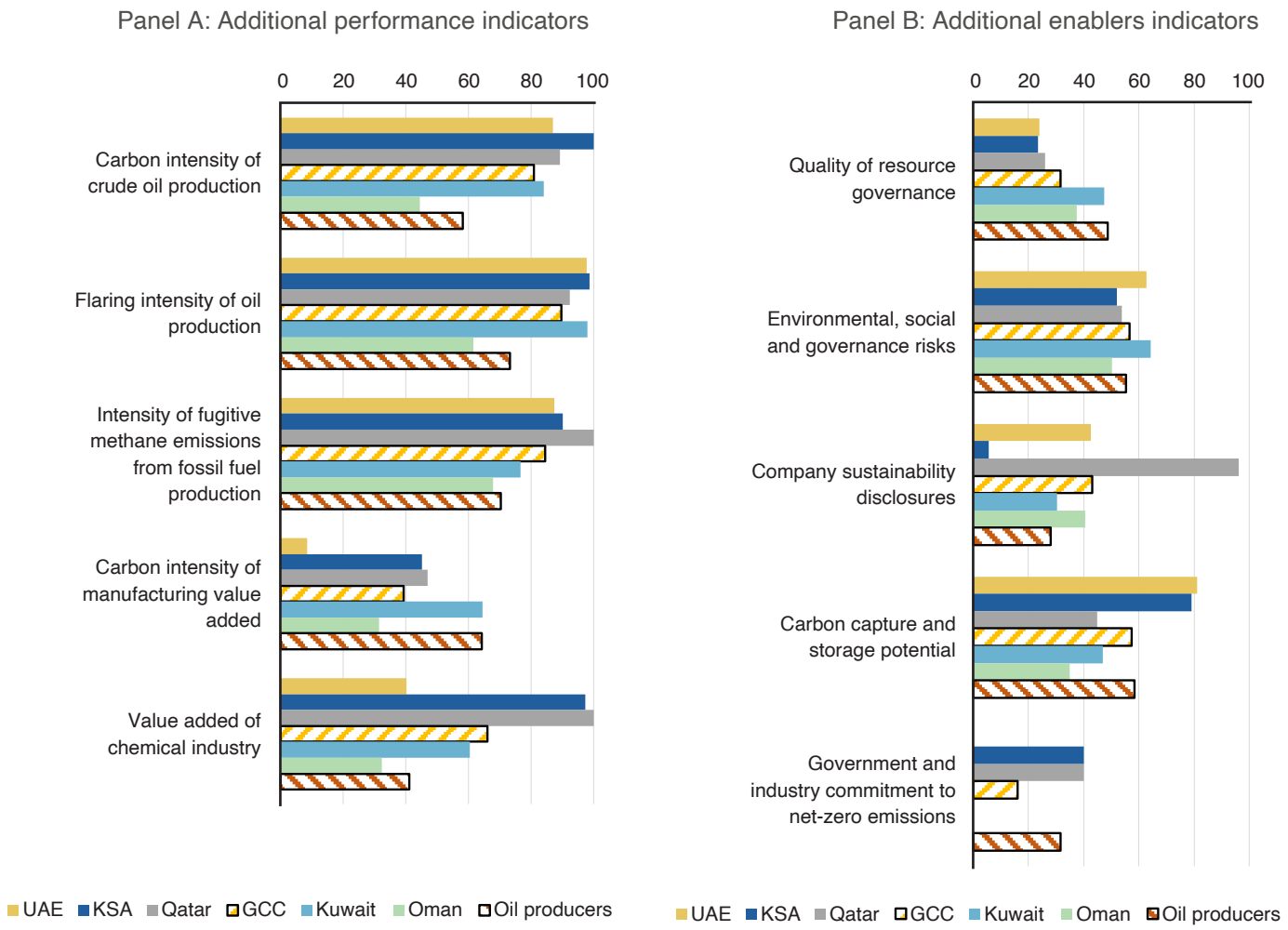


Sources: Authors, based on Luomi, Yilmaz, and Alshehri (2021b); World Bank (2021a).
Notes: GCC does not include Bahrain.

Oil and natural gas continue to play an important role in the five GCC countries' economies, despite their significant progress in economic diversification in recent decades. Based on World Bank estimates, oil rents (i.e., the difference between the value of crude oil production at regional prices and the total costs of production), accounted for an estimated 16%–42% of the five GCC countries' GDPs in 2019.[8] As show in Figure 7, Panel B, which plots the 19 countries' total Oil Producers Lens scores on the y-axis and oil rent reliance on the x-axis, higher economic reliance on oil rents correlates negatively with the countries' scores. One possible reading of this is that economic diversification and CCE transitions are mutually reinforcing. Kuwait, however, is an outlier as it scores higher than what would be expected from its oil rent dependence, as is Saudi Arabia to some extent.

A decomposition of the 10 Oil Producers Lens indicators helps us understand, again, both the similarities and differences among the five GCC countries. The 10 indicators target oil and gas, and other industry-specific metrics both at sector and country levels: Five indicators measure current CCE performance (Figure 8, Panel A) and five focus on enabling factors for CCE transitions (Figure 8, Panel B).

Figure 8. The GCC countries compared with other major oil producers on key CCE metrics.



Source: Authors.
Note: GCC does not include Bahrain.

Focusing first on the Performance indicators (Figure 8, Panel A), overall, with the exception of the carbon intensity of manufacturing value added, the GCC as a group ranks higher than the 19-country group on average on all indicators. Individually, however, there is important variation in the scores.

As the world moves toward net-zero and many countries continue or start pricing emissions, a lower carbon intensity of production will become an asset for oil producers. At present, four GCC countries have among the world's least carbon-intensive crude oil production processes. Saudi Arabia scores 100 on this indicator, which covers a country's production, transportation and refining of crude oil. Oman stands out with a score of only 44.

Flaring and venting remain significant sources of emissions from the oil industry, even while reductions would often deliver cost savings. In 2020, flaring alone was estimated to have generated 377 $MtCO_2$ worldwide, roughly equal to the combined annual emissions of the UAE and Oman (World Bank 2021b; WRI et al. 2021). Again, the GCC

countries, apart from Oman, score high in reducing the amount of gas flared per barrel of oil produced. They also perform well compared with their peers in avoiding fugitive methane emissions from their oil and gas industries, with Qatar scoring the highest and Oman the lowest.

As oil-producing countries diversify their economies both vertically (within the oil and gas sector) and horizontally (beyond the oil and gas sector), the carbon intensity of their manufacturing sectors becomes increasingly important.[9] On the indicator measuring the carbon intensity of their manufacturing value added ($kgCO_2$/US$), all but Kuwait perform well below the 19-country average. The UAE has the second lowest score among the 19 countries (9), only higher than that of Iraq (0). A further analysis to understand the structure of the country's manufacturing industry compared with its peers would be required to identify possible causes.

The chemicals industry is an important area of vertical diversification for Gulf oil producers and has the potential to make a significant economic contribution to CCEs in the region. Qatar and Saudi Arabia receive top scores on chemical industry value added as a share of GDP, while Oman and the UAE rank below the 19-country average. It should be kept in mind, however, that more diversified economies may have higher contributions from other economic sectors, which might explain the UAE's lower score in particular.

Figure 8, Panel B shows the GCC countries' scores on the five oil producer-specific Enablers indicators. A general challenge in measuring this area is that environmental, social and governance (ESG) and broader long-term sustainability-related issues have emerged relatively recently on the global industry's agenda. As a result, there is a general dearth of harmonized datasets that would help measure oil industry preparedness for CCE transitions. The first two indicators, quality of resource governance and ESG risks, draw from existing indices and focus on the country level. On the former, Kuwait stands out for its higher score (48), which is on par with the 19-country average, while the other four score below this average. On the latter, all five receive scores around the broader group's average.

Company sustainability disclosures are used as a proxy of how mainstreamed sustainability and ESG reporting is among oil-producing countries' energy-related industries. It measures the number of reports published by multinational and large energy, energy utility and chemicals companies over the past decade divided by the country's GDP. On this metric, Qatar has a high score (96) with a total of 58 reports registered in the Global Reporting Initiative's database. Saudi Arabia has 21 reports in the database but, due to its larger economy size, scores the lowest (6).

CCS will be a key technology for global oil producers to continue exploiting their hydrocarbon resources as the world transitions to net-zero (IEA 2021b). On CCS potential, which is measured using an existing indicator from the Global CCS Institute's CCS Readiness Index that tracks the development of countries' storage resources, the UAE (81) and Saudi Arabia (79) score well above the 19-group average, while the other three receive lower than average scores.

The final enablers indicator measures the level of government and industry commitment to net-zero emissions. Data for the 2021 CCE Index was retrieved at the end of September 2021, which means the scores do not capture the net-zero announcements made by the UAE, Saudi Arabia, Saudi Aramco (and Bahrain) in October 2021. If these were factored in, the UAE would score 40, on par with Qatar, and Saudi Arabia would score 80.

Conclusion and a Look Ahead: The GCC Countries' Climate Targets and the CCE

The analysis above has shown that, although as a group the GCC countries outperform their neighbors in the Middle East and Africa region and their non-OECD peers in most areas measured by the CCE Index, they should undertake further efforts if they wish to improve their position in the global CCE transition.

Apart from identifying areas where there is scope for further work in individual countries, the analysis also highlighted areas where some GCC countries are leading the way. Individually, among the GCC countries, there are several bright spots: in the area of current CCE performance, Saudi Arabia has made significant progress in switching from oil to natural gas in the power sector and has a significant green hydrogen production capacity in the pipeline. The UAE, in turn, has a sizeable CCUS project capacity and pipeline. However, the GCC as a whole is still lagging behind in renewable energy deployment.

In terms of CCE transition enablers, the GCC countries on average fare very well compared with their peer groups in providing attractive business environments and energy infrastructure stability and security. Their lowest group score is in the area of finance and investment, which is where the largest differences among the five countries also exist. Oman and the UAE have managed to leverage the highest foreign direct investment flows (in proportion to their economy size), and the UAE also scores better than its neighbors in CCE investments and sustainable finance. Even so, all GCC countries still have significant work ahead in scaling up CCE transition finance and investments, including through exploring different carbon pricing instruments.

On many oil producer-specific metrics, some GCC countries' perform significantly better than their peers. Saudi Arabia, the UAE and Qatar perform well in terms of present-day oil industry emissions metrics; major Qatari companies have well-established sustainability reporting practices; and the UAE and Saudi Arabia have well-developed CCS resources. If the recent net-zero targets are factored in, the same three countries — Saudi Arabia, the UAE and Qatar — also score well compared with other oil producers on long-term policy ambition.

While net-zero targets establish a clear, absolute long-term goal (net-zero equals full carbon circularity in which the balance of emissions and removals of CO_2 emissions is zero), they alone tell little about how individual countries and industries plan to reach that goal. Countries' Paris Agreement NDCs generally provide some of this detail for the medium term (currently through 2030 or 2035). The GCC countries submitted their new or updated NDCs to the UN Framework Convention on Climate Change (UNFCCC) between December 2020 and November 2021. Key CCE-related elements featured in these documents are presented in Table 1.

Table 1 seeks to demonstrate how using the CCE as a framework for analyzing countries' emissions plans and targets not only enables comparisons across countries but also allows for an examination of strengths and weaknesses. It also helps to identify possible gaps in countries' internationally communicated climate plans compared with their domestic plans and ongoing developments. The table can also be used to compare GCC countries' 2021 CCE Performance scores with their medium- and long-term plans and targets, to gauge where activities could be expected to be scaled up in the near term.

Table 1. Activities, technologies and targets listed in GCC countries' latest NDCs from 2021 onwards, mapped onto the CEE framework.

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	United Arab Emirates
Energy efficiency	6% EE (energy consumption reduction) target for 2025 (no baseline*)	Energy and water efficiency measures; energy subsidy reforms (only past mentioned)	Improving gas-fired power plants' efficiency by 11% in 2021-2025; other energy and water efficiency measures; subsidy reforms	Energy and water efficiency measures	Energy and water efficiency measures	Reduction of final energy demand by 40% by 2050 (no baseline*); energy and water efficiency measures; energy price reforms (only past mentioned)
Renewable energy	Solar, wind and biogas; 10% peak capacity target for 2035	Increasing renewable energy generation by 2030	20% of electricity from renewables (solar and wind) by 2027 (and 35-39% by 2040)	(800 MW solar plant operational soon)	50% of electricity from renewables by 2030; (plans for solar, wind, geothermal, waste to energy, green hydrogen)	Installed clean power (mainly solar and nuclear) capacity of 14 GW by 2030; renewables and nuclear energy accounting for 50% of installed power generation capacity by 2050
Electrification			Electrification of equipment in the oil and gas industry	Transition to electric vehicles; electrification of port operations	(Electrification mentioned as part of the CCE framework)	2% share of electric and hybrid cars in the Emirate of Dubai's road fleet by 2030
Nuclear energy						Installed clean power (mainly solar and nuclear) capacity of 14 GW by 2030; renewables and nuclear energy accounting for 50% of installed power generation capacity by 2050
Fuel switching		Increasing the share of liquefied natural gas to 70% in energy generation by 2022	Decarbonization of the power sector		50% electricity from natural gas by 2030	(International cooperation in cleaner hydrocarbons welcomed)

Natural sinks	National project for afforestation; mangrove transplantation project	Mangrove cultivation (reductions increasing by 50 kilotonnes of CO_2 per year)		Growing mangroves and planting indigenous trees	Increasing sinks through tree planting, green belts, rehabilitating land, and planting mangroves (blue carbon)	20% of marine blue carbon habitats within protected areas by 2025; planting 30 million mangrove seedlings by 2030
Carbon capture, utilization, and storage (CCUS)	Support to carbon capture and utilization, direct air capture (DAC), other mitigation technologies for hard-to-abate sectors	CCS project(s) resulting in an annual reduction of 216 kilotonnes of CO_2 in 2022		CCS included for new LNG facilities and concepts	Plans to transform industrial cities of Jubail and Yanbu into global hubs for CCUS; enhanced oil recovery; (DAC also mentioned)	Plans to expand CCS capacity; CCS as part of national oil company's GHG emissions intensity reduction target of 25% by 2030 (no baseline*)
Clean hydrogen				(International cooperation in hydrogen fuels and technologies mentioned as important)	650 tons/day of green hydrogen by electrolysis and 1.2 million tons/year of green ammonia produced by 2025; plans for blue hydrogen and National Hydrogen Strategy under development; (clean hydrogen deployment and collaboration mentioned as crucial)	(Pilot electrolysis facility mentioned; international cooperation in hydrogen welcomed)
GHG emissions targets for 2030/2035		7.4% reduction in GHG emissions by 2035 relative to a business-as-usual (BAU) trajectory	7% reduction in GHG emissions by 2030 compared with a BAU trajectory	25% reduction in GHG emissions by 2030 compared with business as usual (no baseline*)	278 million tonnes CO_2e reduction in GHG emissions by 2030 (no baseline*)	23.5% reduction in GHG emissions by 2030, relative to BAU emissions
CO_2/GHG emissions targets for 2050/2060	Net-zero CO_2 emissions by 2060	(Low-emissions development strategy for 2050 planned)			Net-zero CO_2 emissions by 2060	Net-zero CO_2 emissions by 2050

Key

Activities/technologies mentioned. *) Absence of an emissions/other baseline means the absolute target cannot be quantified.

Quantitative target associated with an activity/technology.

Source: Authors, based on the GCC countries' latest NDC documents as of January 3, 2022.
Note: The figure is not exhaustive. Mid-century targets are in many cases not enshrined in the NDCs but have been included in the table as additional information.

First, the table identifies where GCC NDCs contain quantitative (dark blue) versus qualitative (light blue) targets. It shows that most quantitative targets fall under the "reduce" pillar of the CCE, namely renewable energy and energy efficiency. Most GCC countries mention natural sinks in their climate plans, even if their potential may not be as large as that of many other world regions. CCS is also mentioned in most NDCs, but concrete plans or targets still appear to be missing. Hydrogen, in turn, is only mentioned in the UAE's and Saudi Arabia's NDCs, while Oman has also signaled high ambition in this area and recently announced the establishment of a national hydrogen alliance (PDO 2021).

However, some of the quantitative targets mentioned in the NDCs, both for CCE activities and for emissions, do not include baseline information. Baselines are quantitative points of comparison for targets that are expressed in relation to a business-as-usual or other quantitative milestones. A baseline allows for set targets to be quantified by providing a clear point of comparison. In some cases, governments have this information, but for various reasons choose not to disclose it. This means, however, that researchers, for example, cannot conduct policy-relevant scenario and other quantitative analyses in support of effective policymaking. Domestically, baseline information can also help improve policy outcomes by providing all stakeholders with a clear sense of direction. Also, the Paris Agreement calls for transparency in disclosing key assumptions related to targets that countries communicate, as this, among other things, helps quantify the aggregate impact of countries' efforts.

Second, as noted above, the major gap in GCC countries' current CCE performance, measured by the CCE Index, is in the area of renewables (along with nuclear energy, which not all countries can be expected to pursue). Based on the GCC countries' current NDCs, Saudi Arabia, which has set a 50% by 2030 renewable electricity target, and the UAE, which has a 50% clean electricity capacity by 2050 target, can be expected to see significant scaling up of these technologies in the immediate and medium term.

In two CCE activities, namely CCUS and green hydrogen, three GCC countries — Saudi Arabia, Qatar and the UAE — score significantly higher on the CCE Index than their peers. These countries also seem to have somewhat more defined plans in these areas, based on what they have communicated in their NDCs. Given the recent rise in global interest in clean hydrogen, the GCC countries' next NDC updates, which are due by 2025 at the latest, can be expected to contain further details. This is particularly the case for Oman, which has been ramping up its engagement in this area but does not yet refer to hydrogen in its 2021 NDC. CCUS, in turn, will be a critical area for all GCC countries, should they wish to pursue net-zero emissions and CCEs, which is why more detailed plans, by the countries' national oil companies in particular, should also be forthcoming.

There is also significant scope for emissions reductions or avoidance with a minimal or negative cost in the areas of energy efficiency and fuel switching across the GCC. Setting new or higher quantified targets in these areas could help send policy signals to markets and further raise the level of ambition in the GCC countries' NDCs.

Finally, on most CCE activities, there is significant, still unexploited potential for cooperation among the GCC countries in leveraging their similarities and complementarities. An example of the former would be collaborative efforts on major CCUS initiatives and hydrogen exports. There are also major complementarities that a strengthened market around the GCC interconnection grid could bring that could help scale up renewable and other forms of clean energy and increase the rate of electrification across the region.

Endnotes

[1] The CCE Index framework, indicator descriptions, and the score aggregation logic are available in Appendix 1. The full 2021 CCE Index methodology, results, underlying data, and various other resources are available via the web portal: http://cceindex.kapsarc.org/

[2] Libya, which was on the top-20 list of oil producers in 2019, is excluded from the 2021 index due to insufficient data availability. The CCE Index will be updated annually, and the 2022 edition will include a significantly expanded list of countries.

[3] A detailed list of the indicators is available in Appendix 1 and via the CCE Index web portal.

[4] Renewable energy is measured as the total share of renewables, both bio-and non-bio renewables, in total primary energy consumption. This includes modern biofuels, such as bioethanol, as well as traditional bioenergy, including firewood and charcoal. The latter are major contributors to deforestation and often have negative human health impacts. However, excluding bioenergy altogether from this indicator would penalize countries that have high rates of modern biofuel use. The index therefore uses electrification as a control variable, as countries that have high traditional bioenergy use generally have lower rates of electrification. Electrification is also a major enabler for increasing the share of renewable energy in the energy mix. The CCE Index has an indicator for fuel switching away from coal and oil as a control for these fuels in the power sector.

[5] All CCE activities receive an equal weight because finding consensus around a system for different weights (e.g., giving renewable energy more weight) is not possible, as each country prioritizes different CCE activities differently. Also, countries' potential to exploit the different CCE options varies based on their national circumstances, natural endowments, and socioeconomic development levels, and their technology preferences and policy priorities can change over time.

[6] For a long time, nuclear energy was not a feasible option for many countries due to technology, cost and/or geopolitical constraints. However, it is included in the index because it is widely considered a 'clean' energy source, in reference to the fact that nuclear energy itself does not generate CO_2 emissions. Data for nuclear energy is for 2019 and therefore does not account for the UAE's Barakah nuclear power plant, which has been connected to the grid since 2021.

[7] There are two main types of clean hydrogen, green and blue. The 2021 edition of the CCE Index only measures green hydrogen projects because the authors were unable to locate sufficiently comprehensive datasets for blue hydrogen projects. At the same time, blue hydrogen, which relies on CCS, is measured indirectly through the CCUS indicator, which includes any such major projects.

[8] Natural gas rents are not included. These are a significant source of external revenue for Qatar and Oman.

[9] Carbon intensity of manufacturing value added measures the carbon intensity of the energy mix used in the manufacturing sector, the structure of the sector, the energy efficiency of production technologies, and the economic value of the various outputs. Higher levels of industrialization, structural changes in the industry and product diversification generally result in better scores on this indicator, which is also an official Sustainable Development Goal (SDG) indicator. Indicator 9.4.1, CO_2 emissions per unit of value added, measures SDG target 9.4: by 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries acting in accordance with their respective capabilities.

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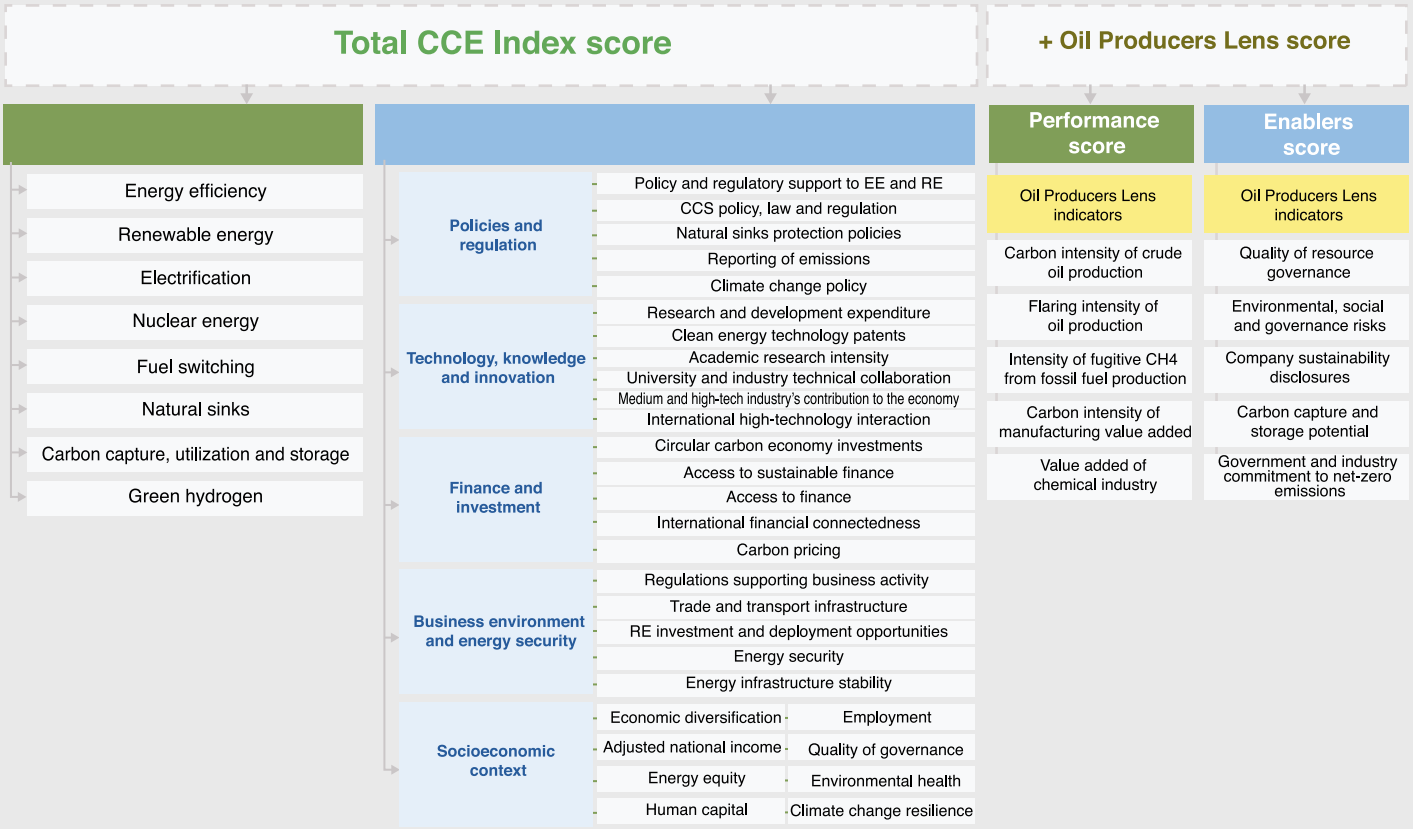
Appendix 1: 2021 CCE Index indicator framework, indicator list and aggregation logic



Sub-index	Sub-dimension	Indicator name	Indicator description
PERFORMANCE	(n/a)	Energy efficiency	Energy intensity of the GDP at purchasing power parities
		Renewable energy	Share of renewables in primary consumption
		Electrification	Share of electricity in total final energy consumption
		Nuclear energy	Share of nuclear electricity in primary consumption
		Fuel switching	Change in the share of oil, coal and lignite and derived gas in electricity production over a five-year period, and overall share of oil, coal, lignite and derived gas in electricity production at the start of the period
		Natural sinks	Ecosystem services, including carbon sequestration and storage, biodiversity habitat, nutrient cycling, and coastal protection (from the Environmental Performance Index)
		Carbon capture, utilization and storage	Total capture capacity of CCUS projects (operational, in construction, advanced development and early development)
		Green hydrogen	Total capacity of green hydrogen projects (commissioned, financed/under construction, and announced/planning begun)
OIL PRODUCERS LENS	Performance	Carbon intensity of crude oil production	Volume-weighted average carbon intensity of crude oil production, transportation and refining by source country (Source Country Upstream and Refining Combined CI)
		Flaring intensity of oil production	Gas flared per barrel of oil produced
		Intensity of fugitive methane emissions from fossil fuel production	Fugitive methane emissions from fossil fuel industry/total fossil fuel production
		Carbon intensity of manufacturing value added	CO_2 emissions per unit of manufacturing value added
		Value added of chemical industry	Value added of chemical industry as a share of the GDP

ENABLERS	Policies and regulation	Policy and regulatory support to energy efficiency and renewable energy	Regulatory Indicators for Sustainable Energy (RISE) indicators for energy efficiency and renewable energy
		Carbon capture and storage policy, law and regulation	CCS Legal and Regulatory Indicator and CCS Policy Indicator (from the CCS Readiness Index)
		Natural sinks protection policies	Average proportion of terrestrial, freshwater and marine key biodiversity areas covered by protected areas
		Reporting of emissions	Fulfilment of reporting obligations under the UNFCCC
		Climate change policy	Climate Policy score (from the Climate Change Performance Index)
	Technology, knowledge and innovation	Research and development expenditure	Research and development expenditure
		Clean energy technology patents	WIPO patent applications/capita (fuel cells, geothermal, solar and wind energy), sum of 5 latest years
		Academic research intensity	Nature Index, 'share'
		University and industry technical collaboration	University/industry research collaboration
		Medium and high-tech industry's contribution to the economy	Medium- and high-tech industry value added (of total manufacturing value added)
		International high-technology interaction	High-technology trade (export and import)/total trade after exluding re-imports/ exports, combined
	Finance and investment	Circular carbon economy investments	Investments in renewable energy, hydrogen, CCS, energy storage, electrified heat and electrified transport, sum of 3 latest years
		Access to sustainable finance	Sustainable (green, social and sustainability-linked) debt (bonds and loans) issued per country of domicile, 5 latest years
		Access to finance	Average (1) domestic credit to private sector, % of GDP, (2) stock market capitalization, % of GDP, and (3) corporate bond issuance volume, % of GDP
		International financial connectedness	Average of (1) foreign direct investment net inflows by foreigners, % of GDP, and (2) foreign direct net outflows by residents, % of GDP
		Carbon pricing	Emissions trading scheme or carbon tax implemented (national level 1, subnational level 0.75), scheduled (0.5) or under consideration (0.25)
	Business environment and energy security	Regulations supporting business activity	Ease of Doing Business score
		Trade and transport infrastructure	Logistics Performance Index
		Renewable energy investment and deployment opportunities	Renewable Energy Country Attractiveness Index
		Energy security	Share of fuel imports of total imports of goods and services (current US$)
		Energy infrastructure stability	Average of System average interruption duration index (SAIDI) and System average interruption frequency index (SAIFI)
	Socioeconomic context	Economic diversification	Economic Complexity Index
		Adjusted national income	Adjusted net national income per capita
		Energy equity	Energy Equity score (from the Energy Trilemma Index)
		Human capital	Human Capital Index
		Employment	Employment to population ratio, 15+, total (modeled ILO estimate)
		Quality of governance	Worldwide Governance Indicators aggregate score
		Environmental health	Mortality rate attributed to household and ambient air pollution, age-standardized
		Climate change resilience	Global Climate Risk Index
OIL PRODUCERS LENS	Enablers	Quality of resource governance	Value Realisation and Revenue Management Scores for oil and gas (from the Resource Governance Index)
		Environmental, social and governance risks	ESG Index
		Company sustainability disclosures	Number of sustainability disclosure reports by multinational and large energy, energy utility and chemicals companies (10 latest years)
		Carbon capture and storage potential	CCS Storage Indicator (from the CCS Readiness Index)
		Government and industry commitment to net-zero emissions	National net zero target in law, policy or under discusssion, and participation in major industry net-zero partnerships

Appendix 1: 2021 CCE Index indicator framework, indicator list and aggregation logic

<table>
<tr><th>Index level</th><th>Sub-index level</th><th colspan="5">Sub-dimension/indicator level</th><th>No.</th></tr>
<tr><td rowspan="3">CCE Index</td><td>Performance score (50%)</td><td colspan="5">Performance indicators (6.25% each)</td><td>8</td></tr>
<tr><td rowspan="2">Enablers score (50%)</td><td colspan="5">Enablers sub-dimensions</td><td rowspan="2">29</td></tr>
<tr><td>Policies and regulation (10%)</td><td>Tech., knowledge and innovation (10%)</td><td>Finance and investment (10%)</td><td>Business env. & energy sec. (10%)</td><td>Socio-economic context (10%)</td></tr>
<tr><td rowspan="4">Oil Producers Lens</td><td rowspan="2">Oil Producers Lens Performance score (50%)</td><td colspan="5">Performance indicators (3.13% each)</td><td>8</td></tr>
<tr><td colspan="5">Oil Producers Lens Performance indicators (5% each)</td><td>5</td></tr>
<tr><td rowspan="2">Oil Producers Lens Enablers score (50%)</td><td colspan="5">Enablers sub-dimensions</td><td rowspan="2">29</td></tr>
<tr><td>(8.33%)</td><td>(8.33%)</td><td>(8.33%)</td><td>(8.33%)</td><td>(8.33%)</td></tr>
<tr><td colspan="5">Oil Producers Lens Enablers indicators (1.67% each)</td><td>5</td></tr>
</table>

Sources: Luomi, Yilmaz, and Alshehri (2021a; 2021b; 2021c).

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About the Project

The Circular Carbon Economy (CCE) Index project seeks to expand and add rigor to the conceptual basis of the concept of the CCE, as well as its practical operationalization, by developing a robust quantitative framework to measure country performance and progress toward it. 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 CCE Index has been designed following international best practices in composite indicator development for country comparisons. A consultation paper from June 2021 provided a preliminary conceptual-methodological framework for the CCE Index and was used by the index team to support related expert and stakeholder consultations. An International Technical Advisory Committee, comprising a group of internationally renowned experts in relevant fields, also supports the delivery of a robust index.

The first edition of the CCE Index, published in November 2021, covers 30 major economies and oil-producing countries. It is being disseminated through various research outputs, including a discussion paper presenting the 2021 CCE Index results, a methodology paper laying out the 2021 CCE Index methodology, and an online platform, located at: https://cceindex.kapsarc.org Further research papers, including this discussion paper, use the CCE Index results to analyze countries in more detail.

The CCE Index has two main functions: first, it is intended to enable further discussions around ways to identify, measure and compare countries' strengths and weaknesses in terms of the CCE, and to help pinpoint areas where progress is already well underway and where further policy efforts are needed or could be beneficial. Second, the index promotes further understanding of the CCE concept and the overall idea of adopting a holistic approach to managing emissions across energy systems and economies and achieving carbon circularity. The project also seeks to support discussions within Saudi Arabia, and other interested countries, on ways to measure, and advance toward CCEs.

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