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

Commentary

How the Circular Carbon Economy Index Can Serve Policymaking: Case Study of Saudi Arabia

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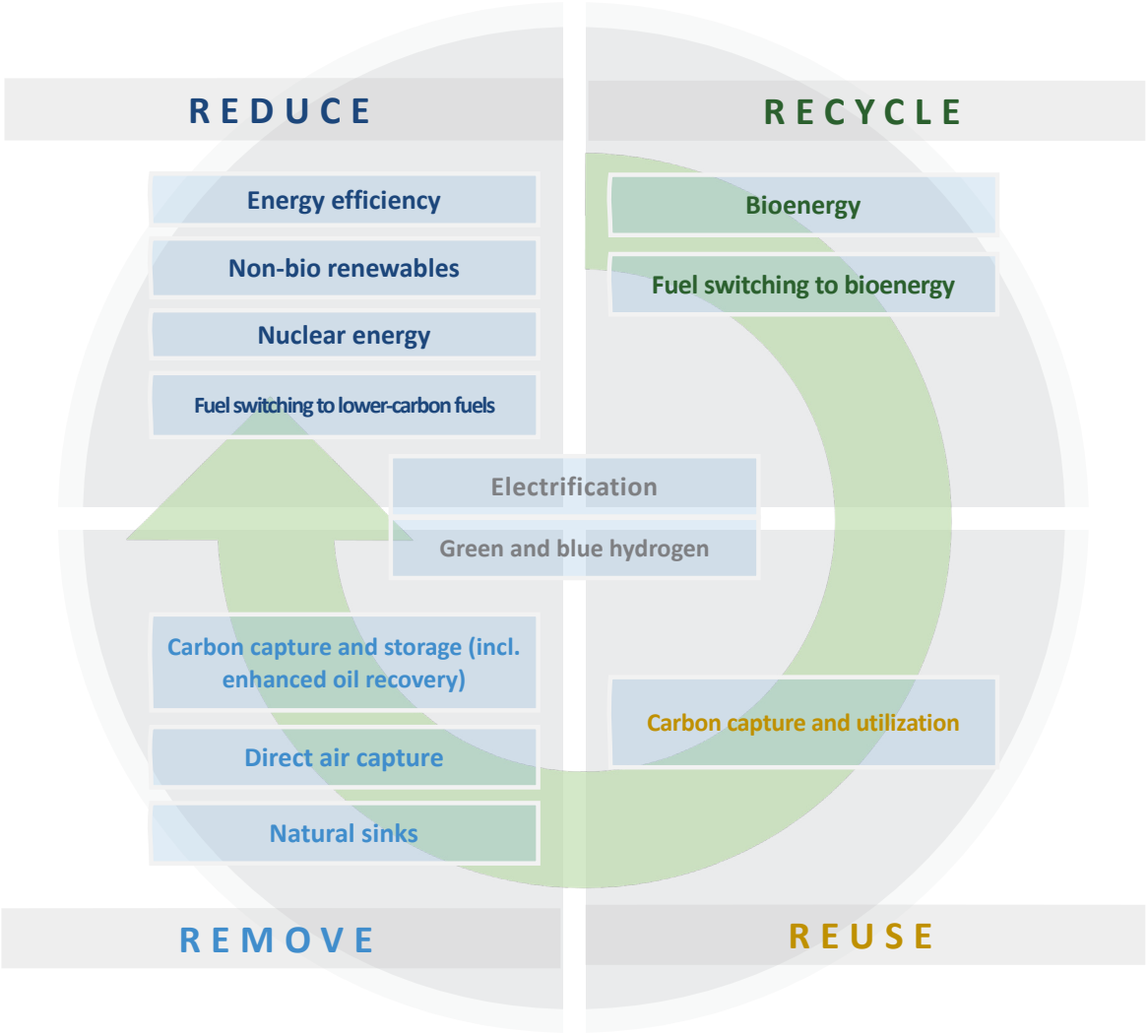
Introduction

The Circular Carbon Economy (CCE) Index is a tool developed by KAPSARC for energy and climate policymakers and stakeholders to quantify and compare country performance and potential on the CCE. The CCE is a relatively new concept. It aims to draw attention to the need to address carbon dioxide and other greenhouse gas emissions holistically by using all available mitigation options cost effectively, through reducing, recycling, reusing and removing carbon or carbon dioxide emissions. Figure 1 illustrates these four 'Rs' and related CCE activities.

Figure 1. The CCE concept.



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

The CCE Index aims to support the use of the CCE framework by countries worldwide by putting forward a set of shared indicators that enhance conceptual clarity and make CCE quantifiable and measurable. The first edition of the CCE Index was launched in November 2021 (Luomi, Yilmaz, and Alshehri 2021a, 2021b). It measures and benchmarks 30 major economies and oil-producing countries on two temporal dimensions: (1) how they are performing and engaging at present with various CCE activities (e.g., energy efficiency, renewable energy, fuel switching, or carbon capture and storage), and (2) how well positioned they are to accelerate progress toward CCEs and carbon circularity going forward.

The CCE Index provides the means for various kinds of policy-oriented analyses and discussions: It can be used to benchmark countries worldwide to compare their relative strengths and weaknesses in policies and performance. It can also be used to examine differences among groups of countries with similar characteristics, to identify common patterns and differences. The index and its component indicators can be used to identify areas of performance and enabling environments that require strengthening to allow for a country to reach its policy goals. Index results can also be compared with targets in national development strategies, to assess how a country's index results might change as it implements these strategies.[1]

This Commentary demonstrates how the CCE Index can be used to analyze a country, in three different ways. It uses Saudi Arabia as a case example, but similar analyses can be conducted for any of the index countries.[2] The Commentary presents:

- A deconstruction of a country's index scores to understand where it stands in comparison with the other countries included in the index, and what its relative strengths and weaknesses are in the areas being measured.
- An examination of a country's results in the context of smaller, more homogeneous country groups, which can result in more meaningful comparisons and help identify possible areas for policy learning.
- An estimation of how a country's index results can be expected to change as it implements its development plans and related policy targets.

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[1] Composite indicators can also help improve data-driven policymaking by prompting discussions on better metrics and data: When examining countries' index scores, stakeholders might also find that the metrics used in the CCE Index are not appropriate for specific national contexts, which can lead them to develop better ways to measure CCE performance and transitions. Gaps in data availability or quality for individual countries might also lead governments and statistical agencies to improve data quality and transparency.

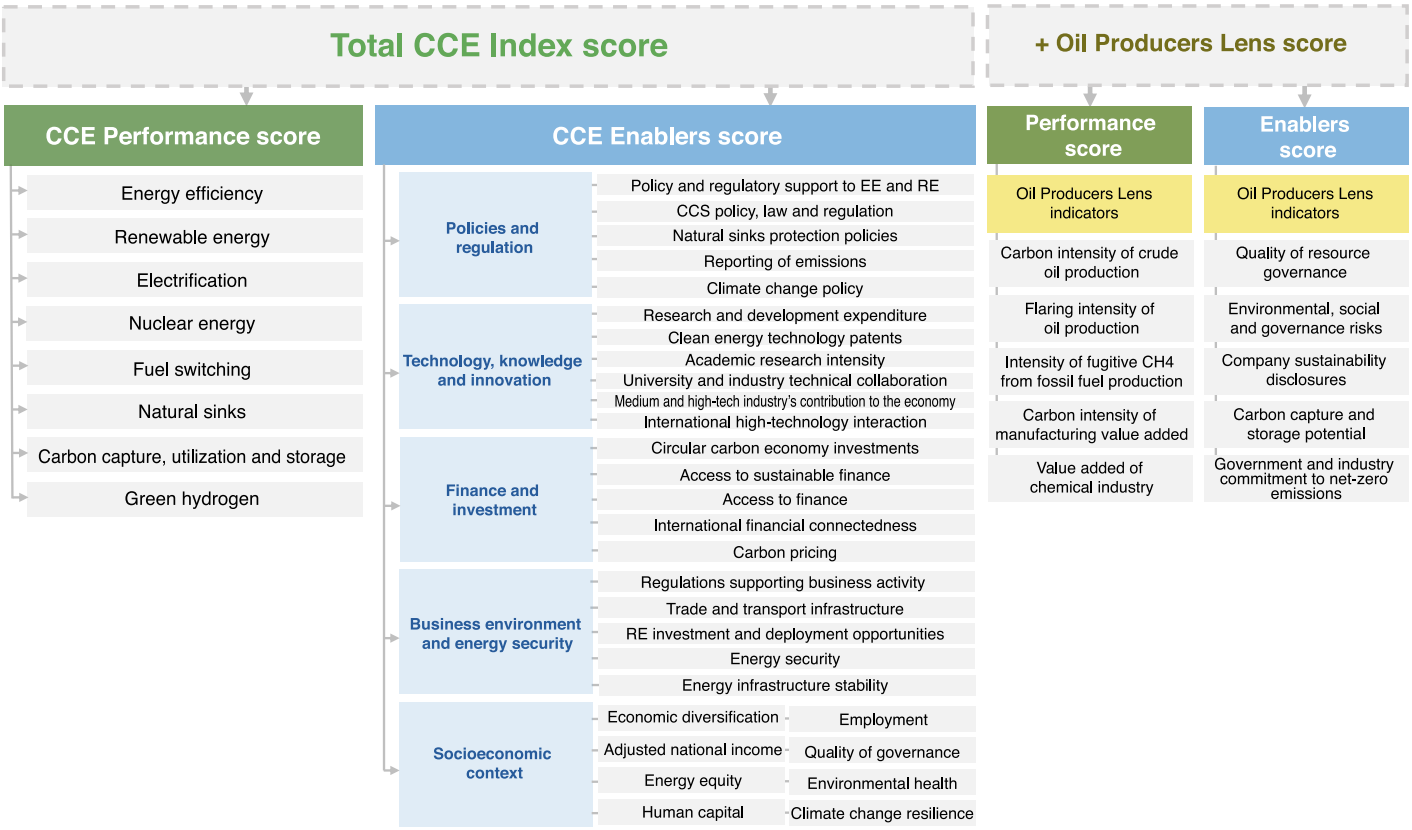
[2] In future editions, the CCE Index will be expanded to more countries, which will enable even further country and group comparisons.

The CCE Index has two parts, or sub-indices: one for measuring countries' current performance on the various CCE activities and the other for gauging how countries are positioned to make progress toward the CCE, based on key enabling factors

The CCE Index

The CCE Index has two parts, or sub-indices: one for measuring countries' current performance on the various CCE activities and the other for gauging how countries are positioned to make progress toward the CCE, based on key enabling factors. The CCE Index also allows for additional comparisons among top oil-producing countries through a separate set of add-on indicators, called the Oil Producers Lens, which helps estimate how these countries' industrial performance and business environments are aligning with the CCE. The 2021 CCE Index indicator framework is displayed in Figure 2. The index uses equal weighting for aggregating the scores (for a detailed description, see Luomi, Yilmaz, and Alshehri 2021a).

Figure 2. The 2021 CCE Index indicator framework.



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

The CCE Index web portal includes features that allow for detailed examinations and visualizations of individual countries' scores and indicator values, and for country comparisons in different reference groups

While this Commentary can be read as a standalone document, two KAPSARC papers that present the methodology and full results of the 2021 CCE Index (Luomi, Yilmaz, and Alshehri 2021a, 2021b) give readers a more in-depth understanding of the index. The 2021 CCE Index results are also available online at: https://cceindex.kapsarc.org. The CCE Index web portal includes features that allow for detailed examinations and visualizations of individual countries' scores and indicator values, and for country comparisons in different reference groups.

Deconstructing the CCE Index score

The first example of how stakeholders can use the CCE Index is a simple deconstruction analysis that compares an individual country's scores with the rest of the countries included in the index. The 2021 CCE Index includes a total of 30 countries: the 19 member countries of the Group of Twenty (G20) and the top-20 global oil-producing countries.[3] As explained above, besides the total index score, the CCE Index has two sub-indices. In addition, the Enablers sub-index has five sub-dimensions. These all are analyzed below, using Saudi Arabia as an example.

Total CCE Index score

The total CCE Index scores for the 30 countries are presented in Figure 3, broken down by sub-index. The total CCE Index scores are simple averages of countries' Performance and Enablers scores, so the proportional differences are the result of countries having a higher score on one sub-index than on the other. A high total CCE Index score indicates that a country is both performing well at present and is also well positioned to make progress toward CCEs and, eventually, full emissions circularity.

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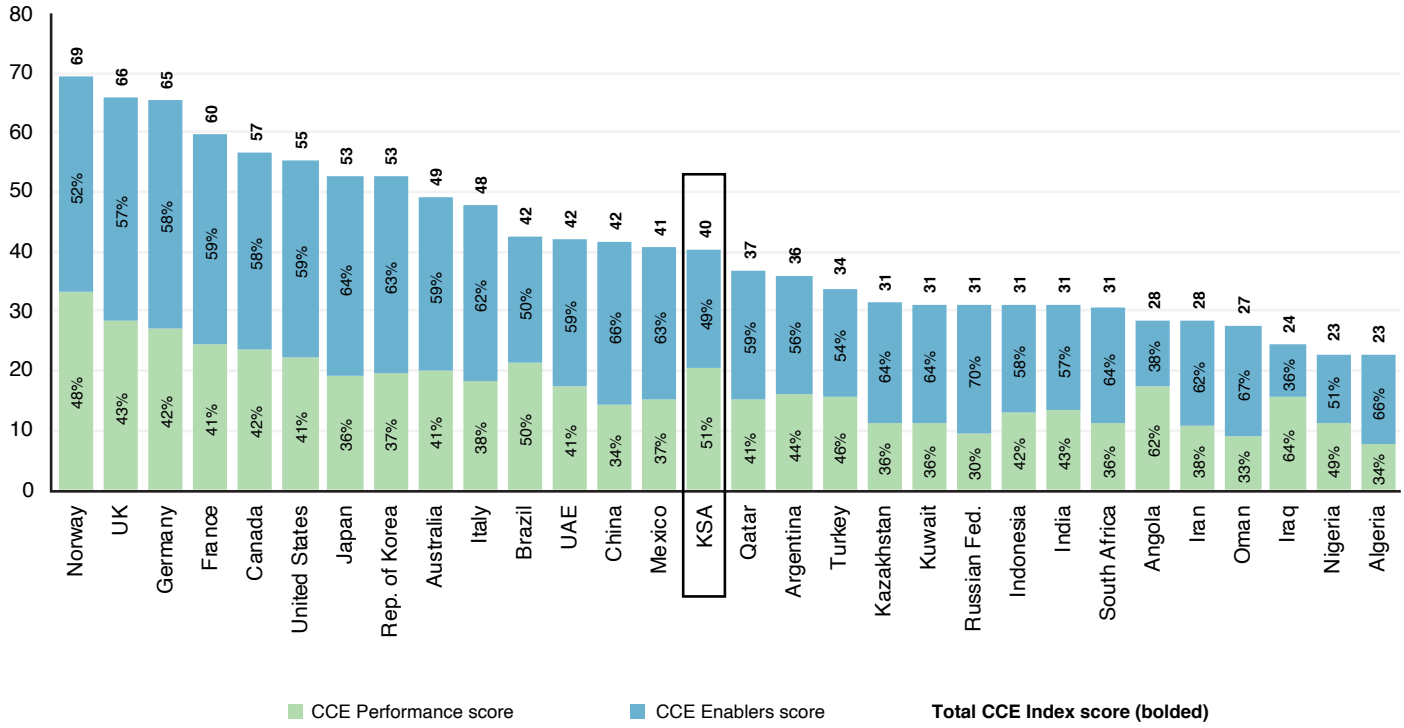
Figure 3. Total 2021 CCE Index scores.



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

[3] Libya is excluded from the 2021 CCE Index due to insufficient data availability.

Saudi Arabia's total score has a slightly higher contribution from the Performance sub-index

Saudi Arabia ranks eighth in the CCE Performance sub-index, with a score of 41, and 20th in the Enablers sub-index, with a score of 40

In the 2021 CCE Index, Norway ranks the highest, with a total score of 69, and Algeria has the lowest score, of 23. Saudi Arabia stands in the middle of the distribution with a score of 40, which is around the 'global' average. While the difference between the top and bottom total scores is significant, many countries in the middle of the distribution have similar results: for instance, Brazil, the United Arab Emirates, Mexico, and Saudi Arabia have minimal differences in their total scores.

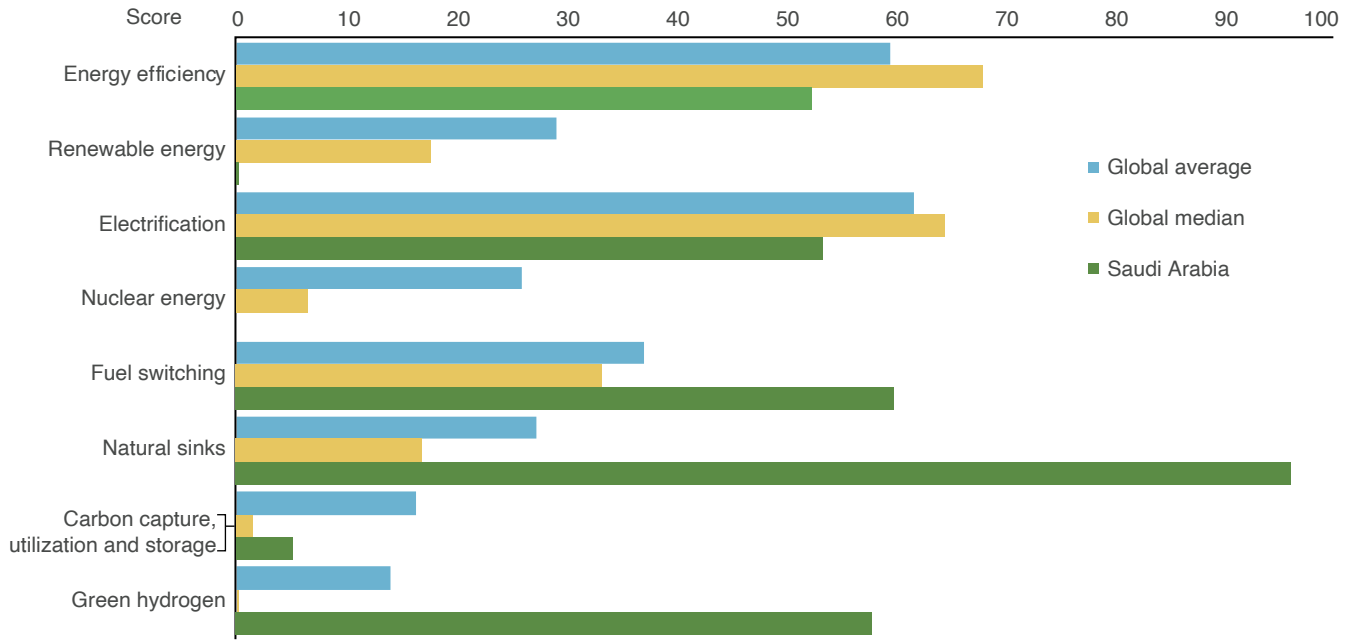
Among the two sub-indices, more countries receive higher scores from the Enablers sub-index than the Performance sub-index. On the contrary, Saudi Arabia's total score has a slightly higher contribution from the Performance sub-index. This is due to its relatively stronger performance in engaging with the various CCE activities: Saudi Arabia ranks eighth in the CCE Performance sub-index, with a score of 41, and 20th in the Enablers sub-index, with a score of 40.

As shown above, high-level examinations of the index results can provide information only about the general status or outlook of countries in comparison with each other. They are less informative about countries' individual strengths and potential areas for improvement, which are crucial for policy planning. The remainder of this section therefore disaggregates the two sub-indices and an Enablers sub-dimension to show how such examinations can provide a richer context on the components underlying the country scores in the case of Saudi Arabia.

CCE Performance score

The CCE Performance sub-index measures how well countries are engaging on the various CCE activities. Saudi Arabia's performance on the indicators measuring each of these activities under the CCE Performance sub-index is displayed in Figure 4 (see also Appendix 1 for a descriptive list of all indicators). The Figure also includes the averages and medians of the other 29 countries included in the index, to allow for a broader benchmarking.

Figure 4. Decomposition of the 2021 CCE Performance sub-index.



Source: Authors' calculations from Luomi, Yilmaz, and Alshehri (2021b).
Note: Global average and median samples exclude Saudi Arabia.

Among the eight activities covered in the Performance sub-index, Saudi Arabia's performance on green hydrogen, natural sinks conservation and fuel switching is particularly strong compared with the two 'global' benchmarks (averages and means).[4] Its performance on energy efficiency and on electrification (which is both a crosscutting enabler for clean energy and a control for non-commercial renewables[5]) is slightly below the global average. In both renewable and nuclear energy, Saudi Arabia still has further expansion potential. While the Kingdom had a renewable energy capacity of 397 MW in 2019 (year or the indicator score; based on data from IRENA 2020), the share in the total energy mix was not yet high enough to register in the index score.

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Green hydrogen and carbon capture, utilization and storage (CCUS) are technologies that are still in the development phase in many countries, and the number of countries with existing or planned capacities is still relatively small. This can be seen in Figure 4, where the median scores for these two technologies is either zero or close to zero. This is because more than a third of the CCE Index countries either do not currently have projects or a project pipeline, or their activities are at very low levels. The Kingdom, on the contrary, has already taken some initial steps to deploy CCUS (through a 0.8-megatonne project in Uthmaniyah and a 0.5-megatonne project in Jubail), and its efforts to deploy green hydrogen are significantly higher compared with most other countries.

Since the CCE Index measures current performance and present-day enabling environments, it does not capture countries' policy ambitions and targets.[6] Saudi Arabia has put forward several major CCE-relevant targets under its Vision 2030 strategy and, more recently, the Saudi Green Initiative, which are expected to accelerate progress in many of the eight CCE Performance areas measured by the index, including renewable energy, fuel switching and energy efficiency. These will be discussed in more detail in the section on *Estimating future CCE Index outcomes*.

Saudi Arabia has put forward several major CCE-relevant targets under its Vision 2030 strategy and, more recently, the Saudi Green Initiative, which are expected to accelerate progress in many of the eight CCE Performance areas measured by the index, including renewable energy, fuel switching and energy efficiency

[4] Green hydrogen performance is measured by countries' existing project pipeline. Natural sinks are measured with the Ecosystem Services indicator score from the Environmental Performance Index. Countries' fuel switching score is a combination of the share of oil and coal in countries' power mix in 2014 and how much they have switched away from these sources between 2014 and 2019. For more details about the indicators, see the CCE Index methodology paper (Luomi, Yilmaz and Alshehri 2021a) or the CCE Index web portal.

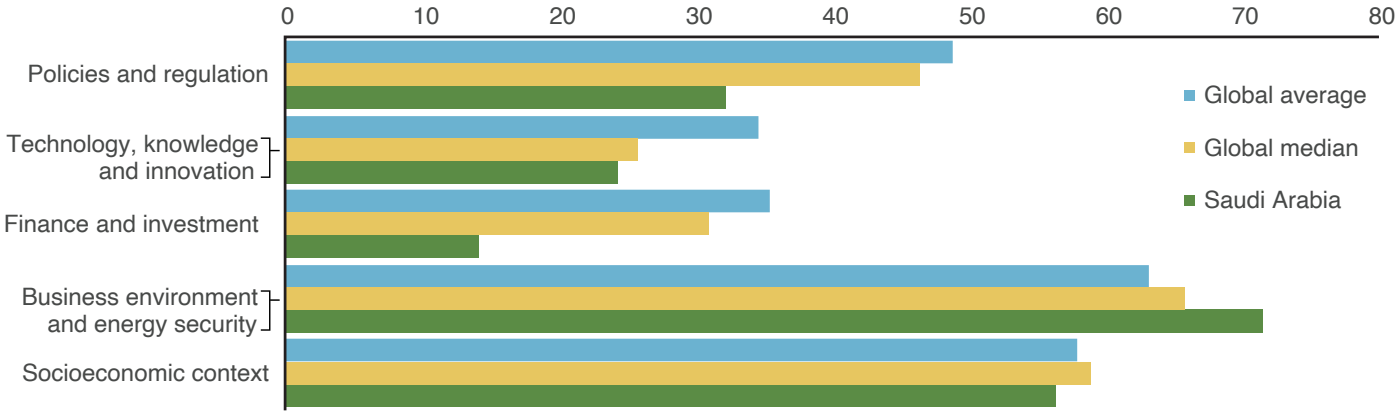
[5] See Luomi, Yilmaz, and Alshehri (2021a) for a more detailed explanation.

[6] The exception is an indicator in the Oil Producers Lens, which gauges commitment to net-zero emissions.

CCE Enablers score

The CCE Enablers sub-index measures countries' potential to accelerate progress toward CCEs. It has five sub-dimensions: Policies and regulation; Technology, knowledge and innovation; Finance and investment; Business environment and energy security; and Socioeconomic context. Each dimension focuses on an area that is crucial for enabling and supporting CCE transitions. Figure 5 presents Saudi Arabia's standing on these five dimensions, alongside the global benchmarks.

Figure 5. Decomposition of the 2021 CCE Enablers sub-index into sub-dimension scores.



Source: Authors' calculations from Luomi, Yilmaz, and Alshehri (2021b).
Note: Global average and median samples exclude Saudi Arabia.

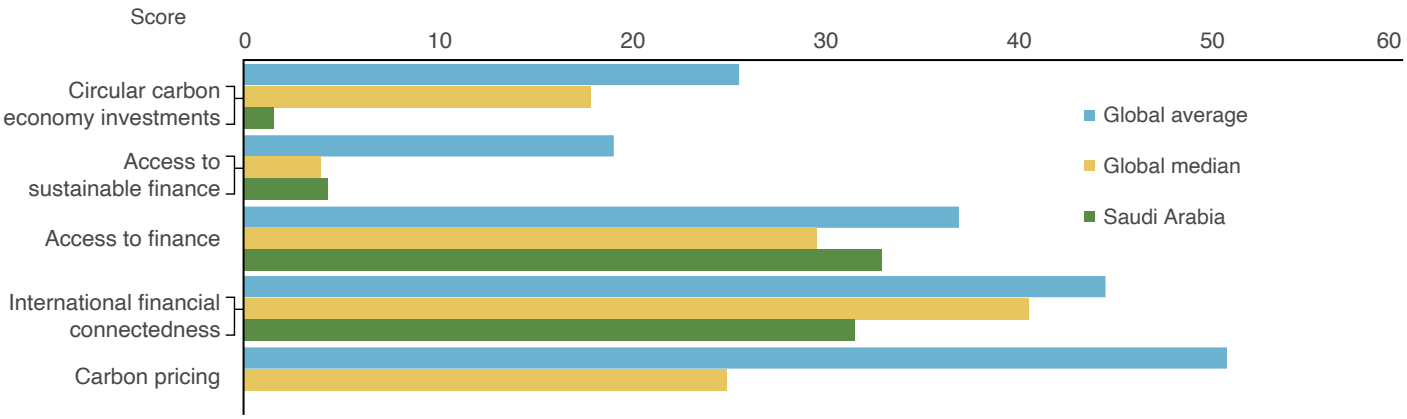
Technology, knowledge and innovation, and Finance and investment, constitute critical enablers for CCE transitions. Yet, the global average and median values are the lowest in these two dimensions, which indicates an urgent need for an accelerated focus on these areas globally

As shown in the figure, countries on average achieve high scores on the Socioeconomic context and the Business environment and energy security dimensions. Saudi Arabia's scores are also high – above or close to the global benchmarks – on these dimensions. The global mean and median values are also relatively high on the Policies and regulation dimension. Here, the Kingdom's position is below the global benchmarks, which indicates an area for possible further focus. Among the five metrics that underpin the Policies and regulation dimension, a higher coverage of protection policies for key biodiversity area, more frequent international emissions reporting, and climate change policy are the areas that could contribute to boosting the Kingdom's position in future index editions (see also Appendix 1).

The two remaining sub-dimensions, Technology, knowledge and innovation, and Finance and investment, constitute critical enablers for CCE transitions. Yet, the global average and median values are the lowest in these two dimensions among the five, which indicates an urgent need for an accelerated focus on these areas globally. Saudi Arabia's position on the Technology, knowledge and innovation dimension is close to the median, although it remains below the average. Among the key indicators under this dimension where focused attention may help the Kingdom strengthen its position are academic research intensity (academic publications), international high-technology interactions (high-technology exports and imports) and clean energy patents (see also Appendix 1).

The Finance and investment sub-dimension merits a closer investigation to better understand what underpins the score and drives Saudi Arabia's results in this area. Figure 6 presents the key metrics under this dimension (see also Appendix 1). The global benchmarks – the average and median scores – in carbon pricing, international financial connectedness (foreign direct investment), and general access to finance (i.e., credit access, stock market and corporate bond market sizes) are higher than in access to sustainable finance (green, social and sustainability-related bonds and loans) and CCE-related energy technology investments. Saudi Arabia's scores are around or close to the benchmarks in general access to finance and international financial connectedness. In the other areas, instruments or deployment are yet to be scaled up.

Figure 6. Finance and investment sub-dimension indicator scores.



Source: Authors' calculations from Luomi, Yilmaz, and Alshehri (2021b).
Note: Global mean and median samples exclude Saudi Arabia.

Overall, there remains significant potential for scaling up sustainable finance and investment not only in Saudi Arabia, but globally, to help accelerate CCE transitions: global benchmarks' scores are relatively low across the five indicators covered under this dimension. As many countries are still in the process of building their environmental, social and governance (ESG) investment frameworks to better position their financial markets with global tendencies and attract more sustainable financial flows, a significant discrepancy exists across their current performance in this area. This discrepancy is also visible in the massive difference between the global average and the global median scores on access to sustainable finance. The underlying aggregate values, based on BloombergNEF estimates (available via the CCE Index web portal), show that a small number of countries, including Norway, France, Germany, the United Kingdom and China, which have relatively more structured ESG infrastructures, dominate issuances in the global sustainable debt market.

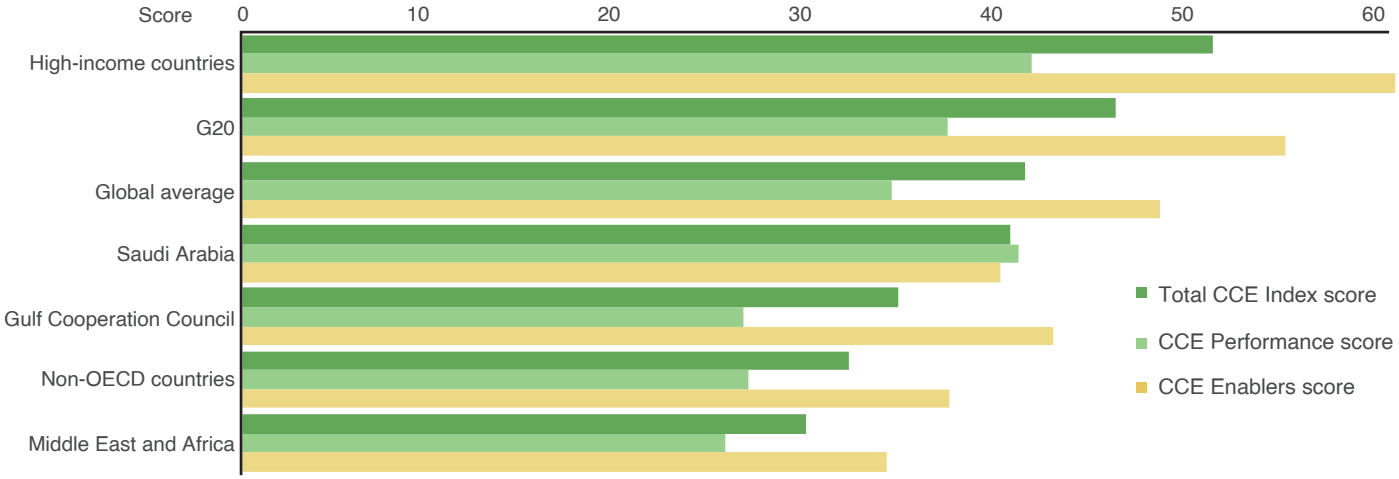
As many countries are still in the process of building their environmental, social and governance (ESG) investment frameworks to better position their financial markets with global tendencies and attract more sustainable financial flows, a significant discrepancy exists across their current performance in this area

Saudi Arabia's total CCE Index score is around the global average and above that of the GCC, non-OECD and Middle East and Africa group averages, while its scores are relatively lower than the high-income and G20 country averages

Comparing the CCE Index score within reference groups

The second way to use the CCE Index is comparing countries within smaller, more homogeneous groups, which can allow for more meaningful comparisons. Such groups for Saudi Arabia include high-income countries, G20 countries, the Gulf Cooperation Council (GCC), the Middle East and Africa region and non-OECD countries. Figure 7 shows these groups, composed of countries included in the 2021 CCE Index edition. The figure includes the average scores for the total CCE Index score, the two sub-indices for these groups, as well as for Saudi Arabia.

Figure 7. Average 2021 CCE Index scores for different country groups.



Source: Authors' calculations from Luomi, Yilmaz, and Alshehri (2021b).
Note: Scores for all groups are averages of the country scores in each respective group, excluding Saudi Arabia. The GCC group does not cover Bahrain, as the country is not included in the 2021 edition of the CCE Index. The total CCE index score is the average of the two sub-indices.

The CCE Index includes an add-on score for its 19 major oil-producing countries, which aims to provide further insights into how these countries' oil and related energy-intensive industries are performing on the CCE and preparing for CCE transitions

As the figure shows, Saudi Arabia's total CCE Index score is around the global average and above that of the GCC, non-OECD and Middle East and Africa group averages, while its scores are relatively lower than the high-income and G20 country averages. Notably, Saudi Arabia records a remarkably high Performance score, which is well above all its peer group averages, except the high-income group, where its standing is close. The Kingdom's Enablers score, on the other hand, is either higher or comparable to the GCC, non-OECD and Middle East and Africa averages, while it remains below the high-income, G20 and global averages.

The CCE Index includes an add-on score for its 19 major oil-producing countries, which aims to provide further insights into how these countries' oil and related energy-intensive industries are performing on the CCE and preparing for CCE transitions. These Oil Producers Lens scores introduce 10 additional indicators, on top of the general 37 CCE Index indicators, focused on countries' oil and gas, and energy-intensive sectors. Saudi Arabia ranks sixth on the total Oil Producers Lens score, third on Performance and 12th on Enablers under the Oil Producers Lens.

While the world's top oil producers share similarities through their hydrocarbon endowments and related industries, they are overall a highly heterogeneous group, in terms of economic structure, income levels, development status and demographics, among other factors. For some countries, oil plays a significant role in the economy, such as for Kuwait, Iraq, Angola and Iraq, where related rent accounts for between a quarter to more than 40% of the GDP. In other economies, despite high production levels, such as the United States, China and United Kingdom, oil rents amount to less than one percent of the GDP. According to the World Bank (2021), in 2019, Saudi Arabia's oil rent to GDP ratio was 24%. (For some context, in 2011, this figure was 50%.)

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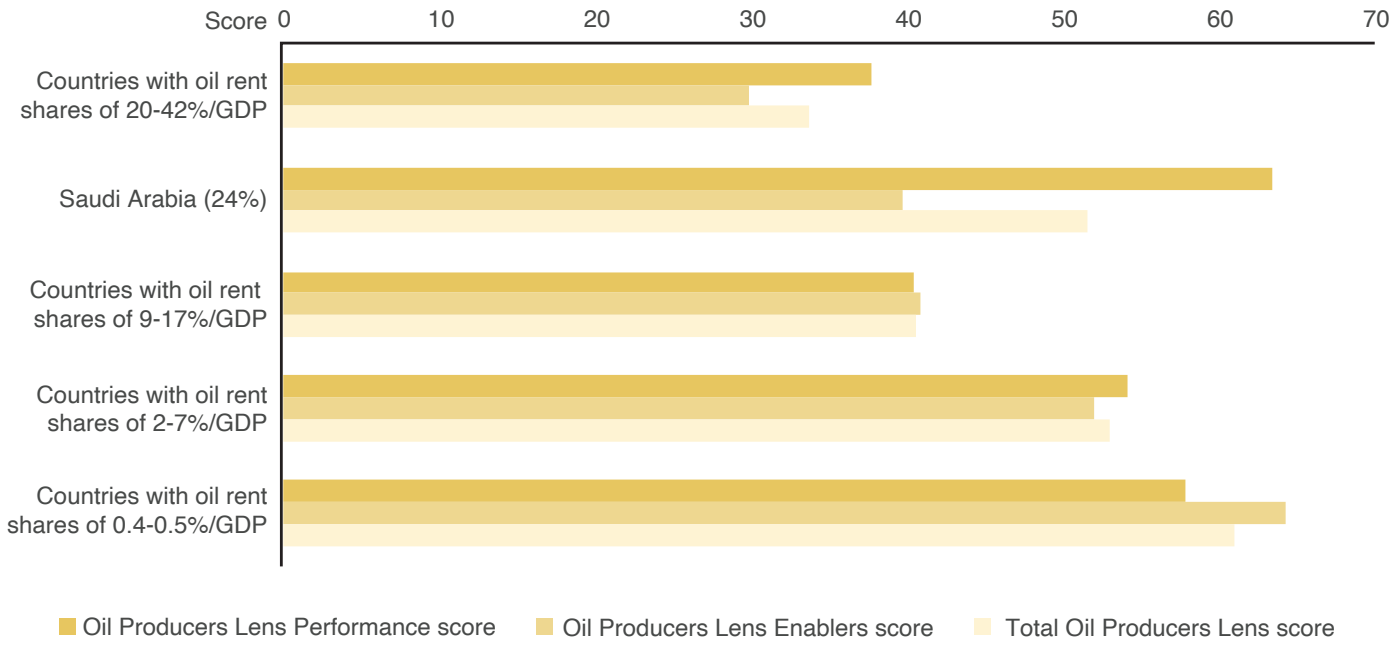
One way to compare countries on the Oil Producers Lens therefore is to examine their index performance in relation to the extent to which oil plays a role in their economies. Figure 8 shows countries in four groups (in addition to Saudi Arabia), based on the share of oil rents in their GDP. Three interesting findings stand out from this visual comparison: First, all Saudi Arabia's scores are higher than the average of other countries with similar rent levels (20–42%/GDP). Second, Saudi Arabia's total Oil Producers Lens score is on par with countries that have rent shares of 2–7%/GDP. Third, the Kingdom's Performance score is higher than any group average, which deserves a closer look.

Figure 8. Oil Producers Lens scores in comparison with the contribution of oil to GDPs.

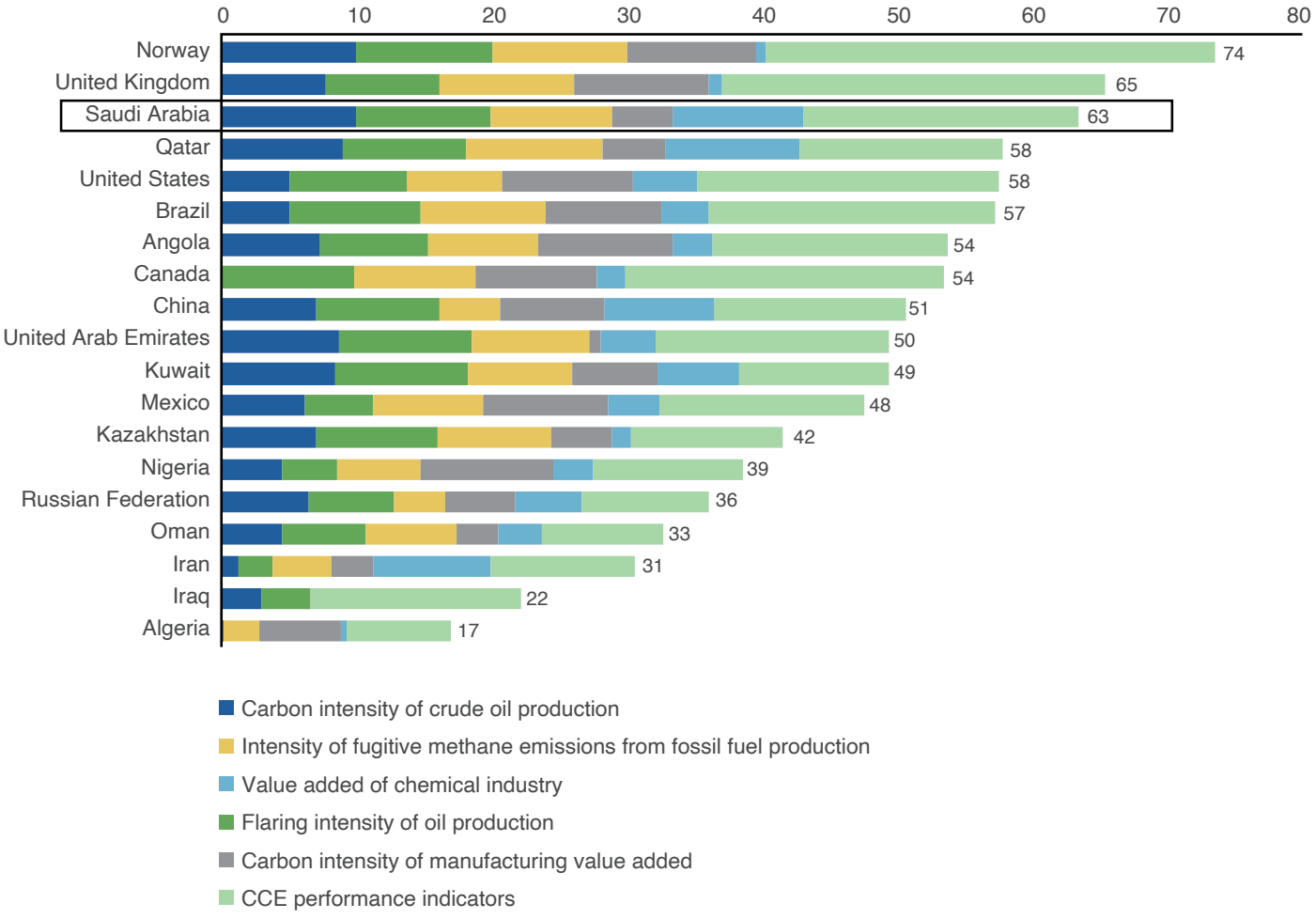


Sources: Authors, based on Luomi, Yilmaz, Alshehri (2021b), and World Bank (2021).
Note: Oil rents are the difference between the value of crude oil production at regional prices and total costs of production. World Bank data is for 2019, except for Iran (2018).

Saudi Arabia achieves high scores across all the five Oil Producers Lens indicators. It ranks in the top five on four indicators, including on the carbon intensity of oil production, where the Kingdom receives a top score

Figure 9 displays the breakdown of the 2021 Oil Producers Lens Performance scores. Half of the score comes from countries' CCE Index Performance score (i.e., the score given on performance to the 30 countries), and the other half from five oil producer-specific indicators, which measure how oil producers are managing carbon circularity in their hydrocarbon and related industries and how efficiently they are generating value from current and future CCE assets. Saudi Arabia achieves high scores across all the five Oil Producers Lens indicators. It ranks in the top five on four indicators, including on the carbon intensity of oil production, where the Kingdom receives a top score.

Figure 9. Oil Producers Lens Performance scores.



Estimating future CCE Index outcomes based on policy priorities and targets

A third way in which the CCE Index can be utilized is to support policy planning and impact assessments. The examples below illustrate how CCE-related national policy goals and targets can be related to indicators underpinning the two CCE Index sub-indices – Performance and Enablers – to allow for assessing, either qualitatively or quantitatively, how a country's CCE Index results may be expected to change as it implements these policies. The CCE performance-related examples draw from the Saudi Green Initiative. Saudi Arabia's Vision 2030 development strategy contains a broad range of targets related to CCE enablers, but the examples below focus on the area of finance and investment.

A third way in which the CCE Index can be utilized is to support policy planning and impact assessments. The examples below illustrate how CCE-related national policy goals and targets can be related to indicators for assessing how a country's CCE Index results may be expected to change as it implements these policies

CCE performance: The Saudi Green Initiative, announced in March 2021 under the patronage of HRH Crown Prince Mohammed bin Salman, is a climate change-focused policy framework that brings existing and new national programs and initiatives related to environmental protection, energy transformation and sustainability under one umbrella.[7] The delivery roadmap for the initiative was launched at the Saudi Green Initiative Forum in October 2021. At the forum, Saudi Arabia also announced a net-zero by 2060 target, which it will pursue through a CCE approach (Saudi Green Initiative 2021b).

Quantitative targets of the Saudi Green Initiative include the aim to plant 10 billion trees in the country, while rehabilitating 40 million hectares of degraded land, and the goal to increase the share of protected areas to more than 30% of the country's total land area. Other major domestic climate change-related focal areas under the initiative include renewable energy projects, carbon capture and storage investments, and initiatives to continue improving energy efficiency (Saudi Green Initiative 2021a, 2021c).

Saudi Arabia also announced a net-zero by 2060 target, which it will pursue through a CCE approach

Alongside the Green Initiative, Saudi Arabia is continuing to diversify its energy mix, and is aiming to increase the share of natural gas and renewables to 50% of electricity production, each (FII Institute 2021a; Al-Iqtisadiyah 2021). The Saudi Public Investment Fund-backed NEOM has set a 100% renewable power supply target, and in 2022, Saudi Arabia's largest solar plant to date, the 1.5 GW Sudair Solar PV Plant, will come online (NEOM 2021; SPA 2021b).

Table 1 shows how these, and other selected CCE-related policy targets and focal areas, relate to the performance indicators of the CCE Index. As can be seen from the table, implementing these policies can be expected to lead to important increases in many of the Kingdom's performance indicator values. Among these metrics, renewable energy is a particularly important one.

[7] The Saudi Green Initiative is part of a two-part initiative. The other part is called the Middle East Green Initiative, which has announced a target of planting 40 billion trees and restoring 200 million hectares of degraded land in the region (Saudi Green Initiative 2021a).

Table 1. Examples of CCE-related policy targets and related CCE Index indicators*

National policy goal/focal area	Relevant CCE Index indicator
CCE Performance	
50% of electricity generated from renewables, and liquid fuels replacement leading to a 50% share of natural gas in the mix (see e.g., Saudi Green Initiative 2021b)	Renewable energy (share of renewables in the energy mix); fuel switching (decreasing the share of oil in electricity generation)
Planting 10 billion trees and rehabilitating 40 million hectares of land	Natural sinks (preserving/enhancing natural carbon sinks)
Initiatives under the Saudi Energy Efficiency Program in the buildings, industry and road transport sectors, which account for more than 90% of domestic energy consumption (see also SEEC 2021)**	Energy efficiency (energy intensity of the GDP)
Saudi Arabia's CCE National Program	Crosscutting
CCE Enablers (finance-related)	
Investments, including into renewables, under the National Investment Strategy	Access to finance Circular carbon economy investments
Green sukuk/bonds issued by the PIF	Access to sustainable finance
Increasing the contribution of foreign direct investment to the GDP to 5.7% (Vision 2030 target)	International financial connectedness
Planned Riyadh Voluntary Exchange Platform for offsets and carbon credits	Carbon pricing***

*) Note: the table is not intended as an exhaustive listing of policies and targets. It provides some major examples only.
**) According to the Ministry of Energy (2021), Saudi Arabia is targeting a domestic energy consumption decrease equivalent to one million barrels of oil per day by 2030, compared with current levels.
***) Voluntary carbon markets are not included in scope of the carbon pricing indicator of the 2021 CCE Index, which draws from the World Bank's Carbon Pricing Dashboard that covers national emissions trading schemes and carbon taxes.

CCE enablers: Vision 2030 is the Kingdom's overarching long-term development and economic reform strategy, which contains numerous qualitative and quantitative policy goals and targets, including further diversifying the economy, and transforming the national oil company Saudi Aramco into a global industrial conglomerate and the Public Investment Fund (PIF) into the world's largest sovereign wealth fund. Qualitative goals of Vision 2030 that are directly relevant to CCE transitions relate to creating a renewable energy sector, deregulating the energy market, expanding natural gas production and petrochemical industries, diversifying the economy, reducing all types of pollution and desertification (Kingdom of Saudi Arabia 2016).[8]

[8] Examples of some of the CCE-related numerical targets enshrined in the document include: lowering unemployment to 7%; increasing the contribution of foreign direct investment to the GDP to 5.7%; and raising Saudi Arabia's ranking in the World Bank's Logistics Performance Index to 25 (Kingdom of Saudi Arabia 2016).

Additional programs[9] and strategies, such as the National Investment Strategy, launched in October 2021, are also supporting the implementation of the Vision. The National Investment Strategy specifically will roll out detailed investment plans for sectors, such as renewable energy and manufacturing, totaling more than SAR 12 trillion (US$3.2 trillion) through 2030 (SPA 2021a). Out of this, SAR 3 trillion (US$0.8 trillion) would come from the PIF, which has since 2017 been positioned as a key 'engine' behind Saudi Arabia's economic diversification and development efforts (SPA 2021a; Kingdom of Saudi Arabia 2021). According to the PIF's Governor, the PIF and its portfolio companies are expected to deliver close to 70% of Saudi Arabia's 50% renewable energy by 2030 target (FII Institute 2021b). The fund is also reportedly working on an ESG framework, planning a green sukuk (Sharia-compliant bond) issuance, and collaborating with the Saudi Stock Exchange Tadawul to establish the Riyadh Voluntary Exchange Platform for offsets and carbon credits for the region (Arab News 2021; SPA 2021c).

Similarly to the CCE performance-related examples, there are direct links between the Kingdom's above-mentioned finance and investment-related initiatives and CCE enablers. Examples are shown in Table 1. Accelerating progress on these, along with the many other policies and goals focused on policy frameworks and enabling business environments, among others, is also likely to see notable increases in indicator values in the CCE Enablers sub-index of future CCE Index editions.

Conclusion

Data and data-based tools, like the CCE Index, can inform better decision-making by providing quantified representations of complex concepts, such as the CCE. This Commentary has sought to provide some initial examples of how the index can be used. It showed how a decomposition of the index scores, reference group analyses and a comparison with national policy targets can generate meaningful insights. These examinations can also open up doors for new questions, such as how much the implementation of different CCE-related policies could be expected to impact countries' individual index performance.

As a case study, the paper examined Saudi Arabia through the glasses of the CCE Index. This brief analysis shows that the Kingdom's position stands currently around global benchmarks. While its Enablers score is lower compared with some of its reference groups, its performance, measured by the breadth of engagement with various CCE activities, is consistently higher than almost all its peer groups. The analysis also points to areas where significant progress has been already made, including lowering the carbon intensity and increasing the efficiency of the hydrocarbon sector, and it identifies areas where the implementation of existing policy targets can help boost the country's competitiveness as the world moves toward carbon circularity.

[9] Eleven Vision Realization Programs, which have been established to support the implementation of Vision 2030, have set numerous quantitative targets and other performance indicators. The programs include the National Transformation Program (focused on economic enablers for the Vision), the National Industrial Development and Logistics Program, the Fiscal Sustainability Program, and the Public Investment Fund Program (Kingdom of Saudi Arabia 2021).

Table 1 shows how these, and other selected CCE-related policy targets and focal areas, relate to the performance indicators of the CCE Index. Implementing these policies can be expected to lead to important increases in many of the Kingdom's Performance indicator values

There are direct links between the Kingdom's above-mentioned finance and investment-related initiatives and CCE enablers. Accelerating progress on these, along with the many other policies and goals focused on policy frameworks and enabling business environments, among others, is also likely to see notable increases in indicator values in the CCE Enablers sub-index of future CCE Index editions

Data and data-based tools, like the CCE Index, can inform better decision- making by providing quantified representations of complex concepts, such as the CCE

Appendix 1. Descriptive list of the 2021 CCE Index indicators.

Nb. For comprehensive indicator details, see Luomi, Yilmaz, and Alshehri (2021a) or the CCE Index web portal at: https://cceindex.kapsarc.org

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

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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 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 project consists of various components, including a consultation paper, published in June 2021, which provided a preliminary conceptual-methodological framework for the CCE Index and was used by the index team to support related expert and stakeholder consultations. The CCE Index also convened an International Technical Advisory Committee, with five initial members, to help improve the robustness of the index methodology.

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

The CCE Index has two main functions: first, the index 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 to 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.

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.

Legal Notice

Corrigendum

This paper has been updated on March 3, 2022 to account for an error in the 'environmental health' indicator, which has a descending score range. The previous version used an ascending score range. The change results in minor changes to country scores and rankings.

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