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King Abdullah Petroleum Studies and Research Center

What Drove Saudi Arabia's 2020 Fall in CO_2 Emissions?

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Instant Insight

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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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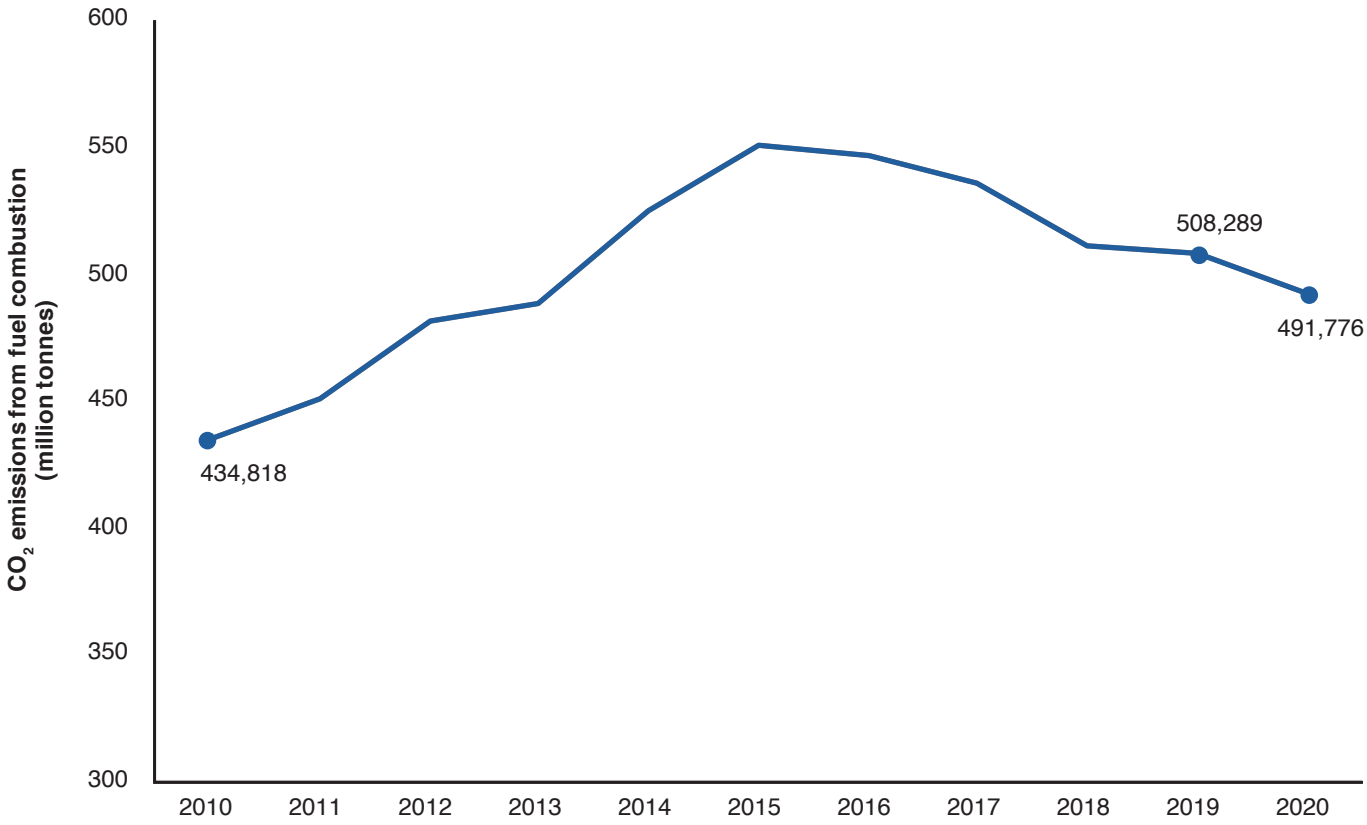
What has happened?

In June 2021, the energy data provider Enerdata released its initial estimates for Saudi Arabia's 2020 carbon dioxide (CO_2) emissions.[1] The data indicate that the Kingdom's CO_2 emissions from fuel combustion decreased by 3.3%, from 508.3 million tonnes of CO_2 ($MtCO_2$) in 2019 to 491.8 megatonnes of CO_2 ($MtCO_2$) in 2020 (Figure 1).

Figure 1. Saudi Arabia's CO_2 emissions from fuel combustion (2010–2020).



Source: Authors based on Enerdata Global Energy & CO_2 Database.
Based on: Enerdata, IEA, JODI and SAMA (2019 – 2020 data) and IEA (2018 and earlier).

[1] Carbon dioxide (CO_2) is the most abundant human-made greenhouse gas (GHG), which accounts for approximately three-quarters of global GHG emissions and an estimated 80% of Saudi Arabia's total GHG emissions in CO_2-equivalent (Climate Watch 2021). Most data providers focus on CO_2 emissions from fuel combustion, which are easier to estimate at a greater frequency. Available data on the breakdown of GHG emissions are characterized by large uncertainties, and sectoral breakdowns are by and large not available.

The 3.3% drop in the Kingdom's CO_2 emissions was less than a previous KAPSARC analysis predicted – a reduction of between 4% in a scenario in which pre-pandemic conditions would have returned by mid-June 2020, and 7% in which restrictions would have stayed in place until the end of 2020 (Howarth et al. 2020).

Figure 1 also shows that annual CO_2 emissions in the Kingdom have steadily decreased since 2015. The decline was mainly driven by the energy price reforms in 2016 and 2018; the fuel mix policy that aims to phase out oil products in the electricity sector; and robust energy efficiency regulations across the buildings, transport, and industrial sectors. Despite the impacts of COVID-19 last year, the largest year-on-year decrease occurred in 2018 (4.6%), with the 2020 decrease being the second largest. The 2018 decline is attributed to policies such as energy price reform, the expatriate levy, the value-added tax, in addition to the drivers mentioned above (Aldubyan and Gasim 2021).

The 2020 fall in Saudi emissions occurred against the backdrop of a significant impact on energy demand and emissions from various government measures implemented to combat the pandemic (Box 1).

Box 1. Selected pandemic control measures in Saudi Arabia in 2020.

- The Saudi government took swift action in implementing restrictions to tackle the spread of COVID-19 after recording its first case at the start of March 2020. By mid-March, Saudi Arabia enforced remote working for all employees (SPA 2020a) before suspending domestic flights, public buses, trains, and taxis on March 21 (SPA 2020b). The government declared a curfew just two days later (SPA 2020c), with non-essential commercial activities coming to a halt.

- The curfew was extended at the start of April (SPA 2020d), but the government had partially lifted it by the end of that month (SPA 2020e), allowing some commercial activities to resume. Domestic flight services also resumed at the end of May (SPA 2020f).

- International flights remained suspended, but the government lifted the curfew entirely by the end of June, with many employees returning to their workplaces (SPA 2020g). Still, the government continued to require the use of preventative measures and procedures in all sectors after lifting the curfew (SPA 2020h).

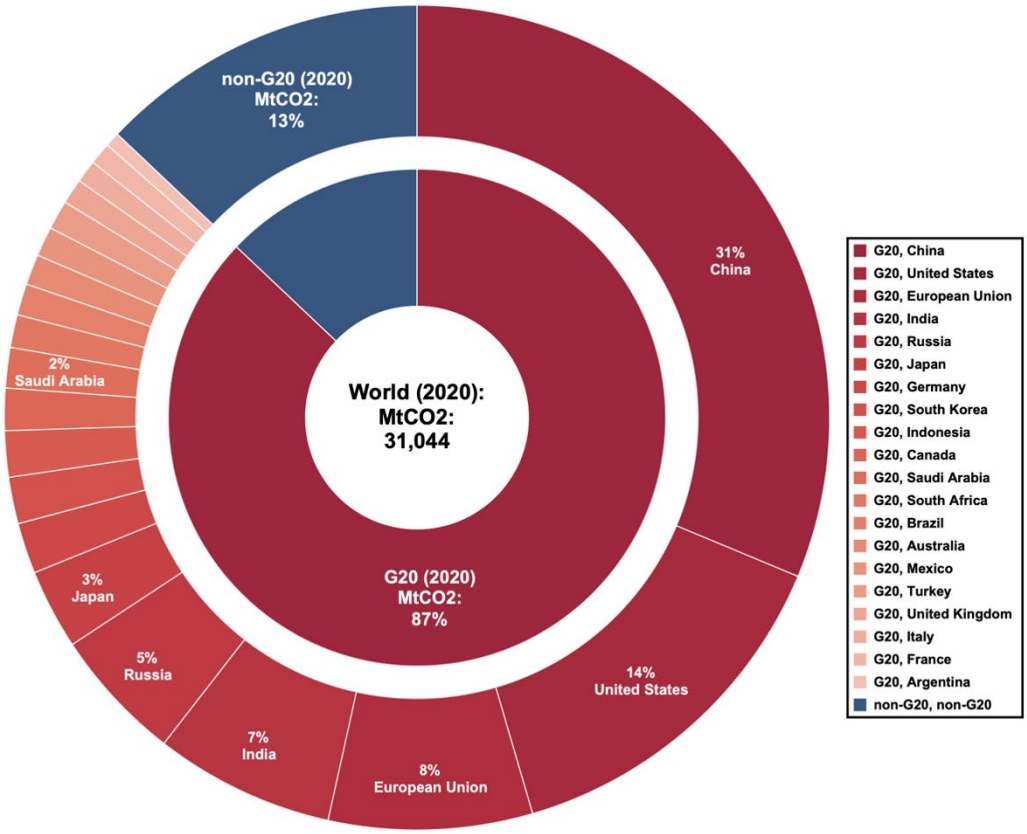
- By the end of August 2020, the government required all public sector employees to return to their workplaces (SPA 2020i), with firms in many other sectors following suit. By the end of 2020, international flights remained suspended despite the easing of many restrictions, and schools and universities continued providing education remotely (SPA 2020j, 2020k).

The COVID-19 restrictions affected domestic energy demand and CO_2 emissions in Saudi Arabia through direct and indirect channels. For example, the curfew-related restrictions on mobility caused sharp drops in domestic gasoline and kerosene consumption during the second quarter of 2020 (Gasim 2021). In addition, the pandemic and ensuing restrictions led to a decrease in Saudi real gross domestic product (GDP), a key driver of energy demand and emissions.

How do Saudi Arabia's 2020 CO_2 emissions compare with other G20 countries?

The COVID-19 pandemic led to significant decreases in emissions worldwide in 2020. Based on some estimates, global CO_2 emissions fell by 6.4% that year, driven by reduced economic and social activity (Tollerson 2021). Over the last decade, the Group of Twenty (G20) countries were on average responsible for about 85% of global CO_2 emissions from fuel combustion (Figure 2).

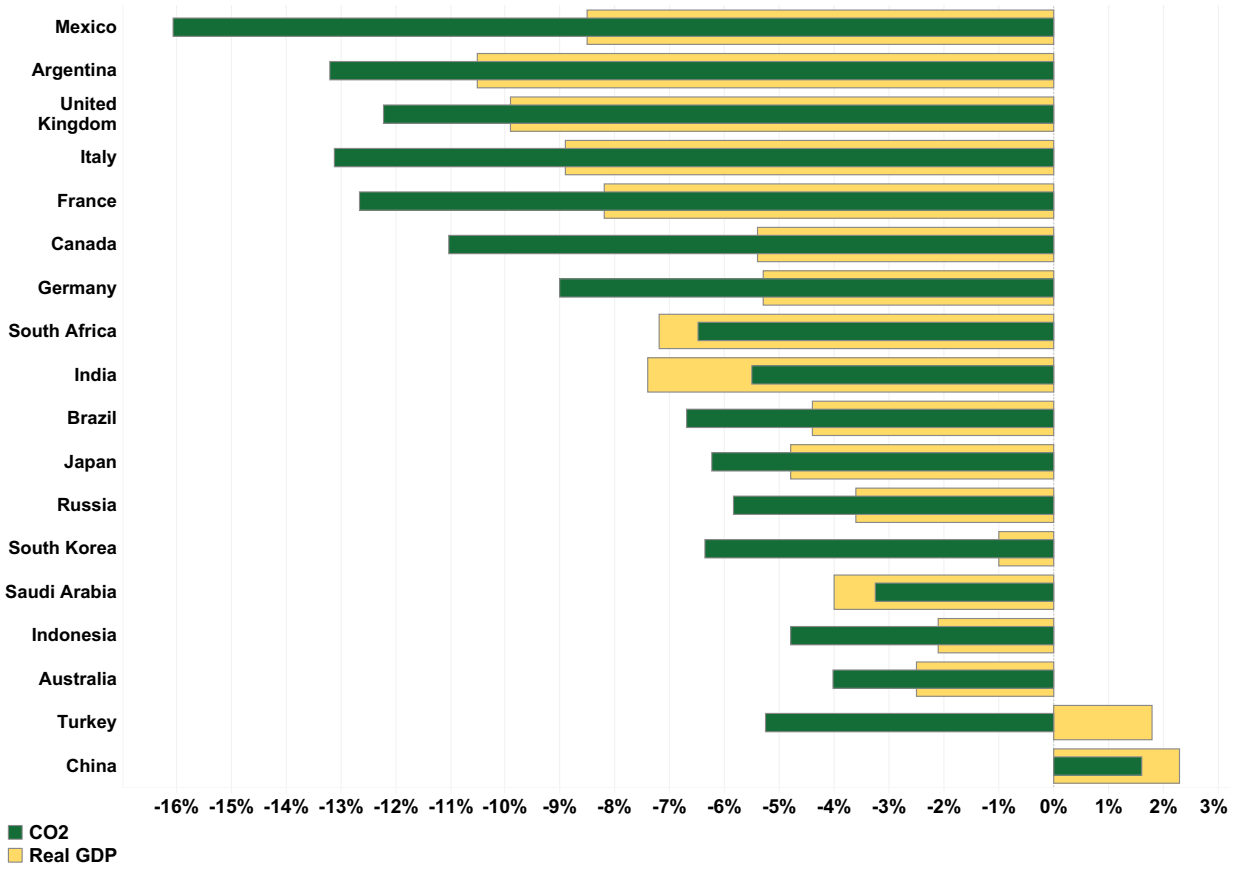
Figure 2. G20 and non-G20 CO_2 emissions from fuel combustion (Mt) and share of world total (%) in 2020.



Source: Authors based on Enerdata Global Energy & CO_2 Database.

In 2020, across most of the G20, there was a massive drop in CO_2 emissions from fuel combustion, largely in line with the fall in economic activity measured by GDP. Together with South Africa, India, and China, Saudi Arabia was one of four G20 emerging economies whose change in GDP exceeded their change in CO_2 emissions on a year-on-year basis (Figure 3).

Figure 3. The 2019-2020 percentage change in CO_2 emissions from fuel combustion and real GDP (preliminary).[2]



Source: Authors based on Enerdata Global Energy & CO_2 Database.
Note: G20 comparison based on emissions from fuel consumption, as total CO_2 emissions is not available for all countries.

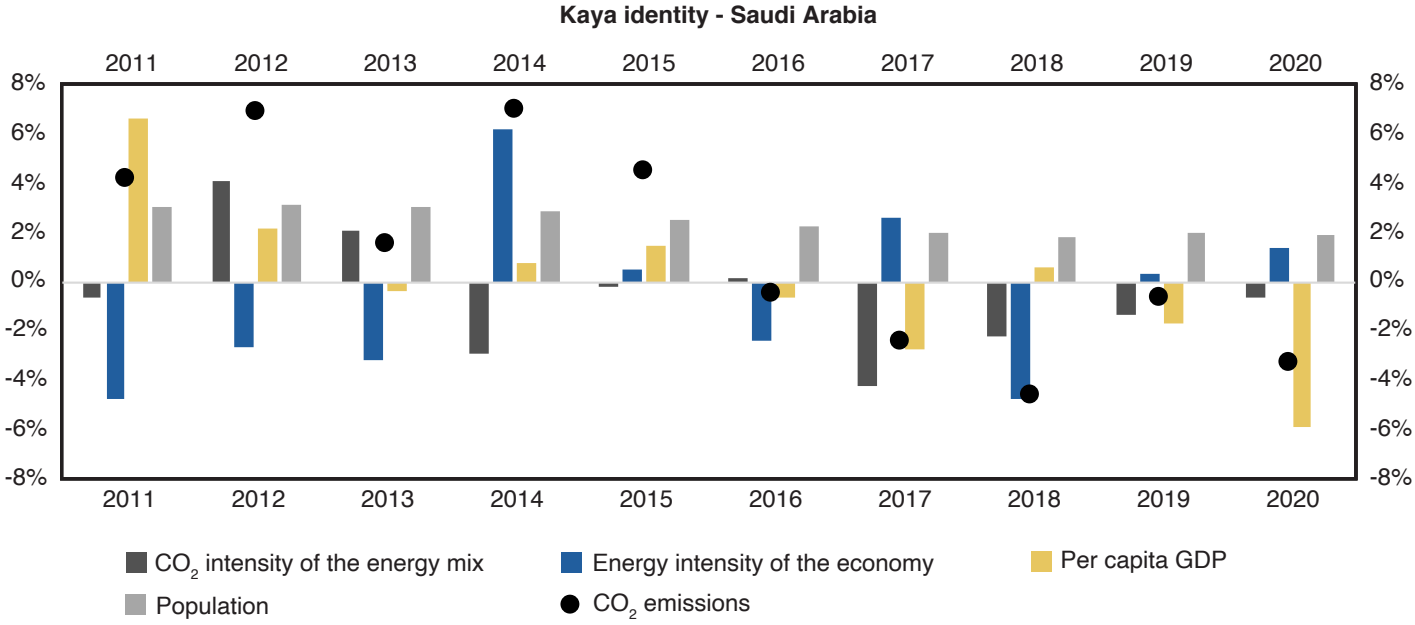
It can be challenging to explain the drivers of the relative changes in GDP and emissions in 2020 across G20 countries, given the diversity of their circumstances and how they were affected by and responded to the pandemic. As noted above, in some emerging economies, real GDP fell by more than emissions. The opposite was true for Russia, Brazil, and Mexico. Given that Saudi Arabia and Russia are both leading oil exporters, the existence of a large oil and gas production sector also does not alone explain these trends. It could also be expected that the stringency of lockdown measures would influence these trends. However, Saudi Arabia, India and China all enforced strict lockdown measures early on during the pandemic but had different GDP and emissions outcomes. The length of time the restrictions were in place is also an important factor to consider. For example, China lifted its stringent restrictions earlier than other countries, which probably allowed economic activity and emissions to rebound slightly faster.

[2] Regarding the 'outlier data' for Turkey, Enerdata indicates that a possible explanation for the drop in CO_2 emissions in Turkey is a significant fall in CO_2 emissions in the energy sector (from fuel combustion) dropping by 17% and CO_2 from coal combustion in public electricity and heat production dropping by 14% between 2019-2020. In addition to this, Turkey's 2020 GDP growth was driven by investment expenditures and imports and not by the domestic production of goods and services.

What major factors underpinned the change in CO_2 emissions in Saudi Arabia in 2020?

Emissions can be understood as a function of four major components: population growth, per capita economic growth, changes in the energy intensity of the economy, and emissions intensity of the energy mix. This equation, known as the Kaya identity, is illustrated for Saudi Arabia in Figure 4.[3] Similar to other countries, the year-on-year fall in emissions in Saudi Arabia was primarily driven by the fall in its economic activity, which pushed its GDP per capita down by an estimated 5.8% while its population growth remained constant, at around 2%. Saudi Arabia's GDP per capita growth has been slowing through the 2010s, but in 2020 it made the single largest contribution to its emissions trends.

Figure 4. Kaya identity for change in CO_2 emissions from fuel combustion in Saudi Arabia, 2011–2020*.



Source: Authors based on Enerdata Global Energy & CO_2 Database. Based on: Enerdata, IEA, JODI and SAMA (2019 – 2020 CO_2, TPEC), IEA (2018 and earlier), CO_2 (TPEC), World Bank (Population, GDP 2015 constant purchasing power parity terms).

[3] The Kaya identity equation for change in CO_2 emissions used in the figure is:

$$\Delta CO_2 = \Delta \frac{CO_2}{TPEC} + \Delta \frac{TPEC}{GDP} + \Delta \frac{GDP}{POP} + \Delta POP$$

Where:

- CO_2 is carbon emissions from fuel combustion.
- TPEC is total primary energy consumption (energy consumed in the domestic economy).
- GDP is GDP in U.S. dollars (US$) at constant purchasing power parity (2015).
- POP is population.

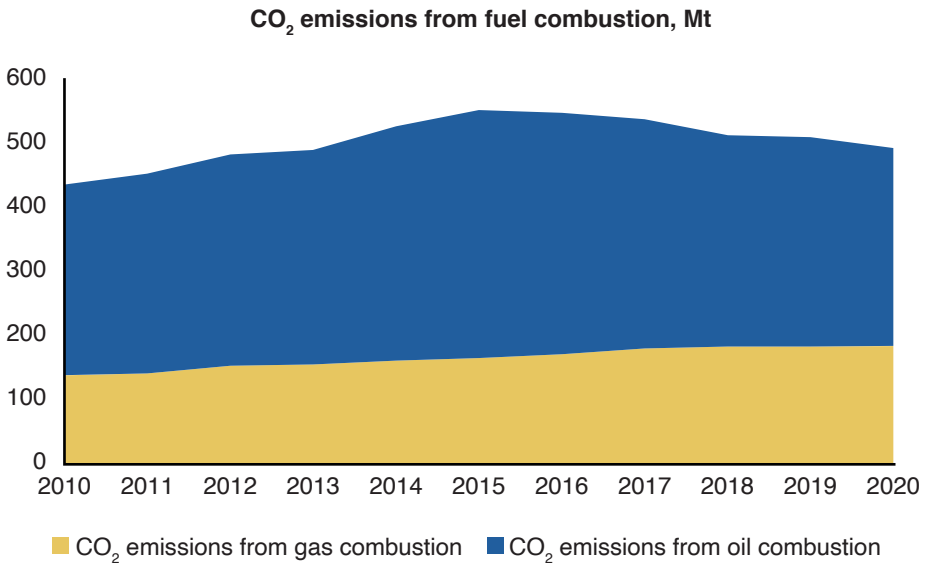
Energy intensity generally improves as a country's production processes become more energy-efficient, or as a country moves away from energy-intensive manufacturing toward services. Saudi Arabia's energy intensity performance has fluctuated in recent years, but 2020 appears to have followed a similar pattern to 2019. In 2020, Saudi Arabia's energy intensity increased by an estimated 1.4%. For comparison, to reach the United Nations Sustainable Development Goal (SDG) 7 (Affordable and Clean Energy) target of doubling the global rate of improvement in energy efficiency, countries' energy efficiency should improve by 3% each year, on average (UN DESA 2021). One possible explanation for the increase in Saudi Arabia's energy intensity could be that the economic sectors most affected by the pandemic (e.g., services) were not energy-intensive, which led to a higher share of economic output from energy-intensive industries (IEA 2020).

The final component of the Kaya identity, the carbon intensity of the energy mix, is influenced by two drivers: the emissions intensity of the fossil fuels used (e.g., fuel oil has a significantly higher CO_2 intensity than natural gas) and the share of fossil fuels in the energy mix. The carbon intensity of Saudi Arabia's energy mix has decreased since 2017, albeit at a decelerating pace: In 2017, its carbon intensity decreased by 4.2%, whereas in 2020, this rate was only 0.6%. Given the low levels of non-fossil fuel energy sources in the country's energy mix, a slowing of switching to lower-carbon intensity fossil fuels is the likeliest explanation.

How did Saudi Arabia's CO_2 emissions change?

Figure 5 shows year-on-year changes in CO_2 emissions from fuel combustion in the Kingdom over the past decade. Three broad trends can be identified, which all appear to be somewhat unaffected by the pandemic. First, CO_2 emissions from natural gas combustion have been increasing steadily over the past 10 years. Second, CO_2 emissions from oil products have been falling since 2015, which, third, has driven an overall decrease in fossil fuel combustion-related CO_2 emissions. The year-on-year fall in oil-related emissions in 2020 was steep, at 5.4%, but this was on par with the reduction in 2017 (5.3%) and less than the fall in 2018 (7.6%).

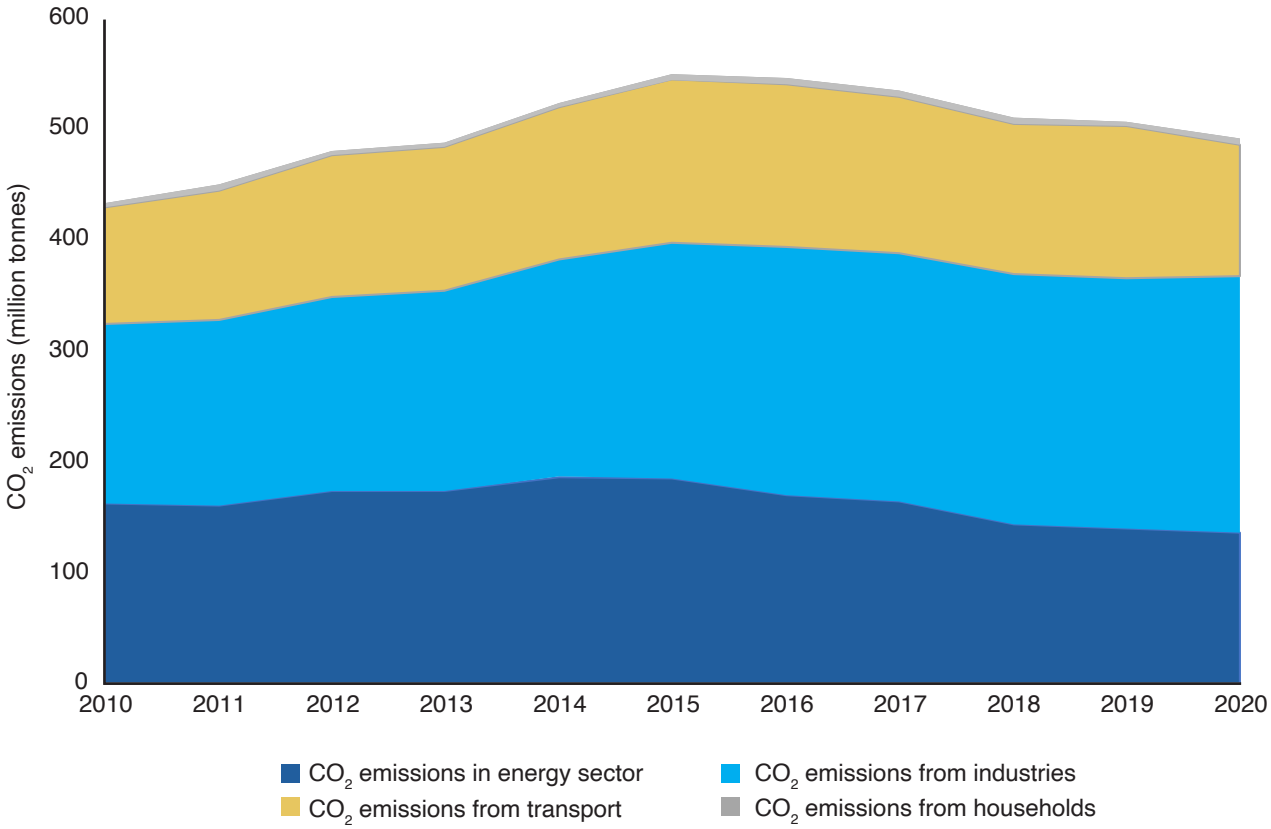
Figure 5. CO_2 emissions from fuel combustion per main fuel in Saudi Arabia, 2010–2020.



Source: Authors based on Enerdata Global Energy & CO_2 Database.
Based on: Enerdata (2018) and IEA (2017 and earlier).

An examination of sectoral CO_2 emissions provides additional insights. Overall, the industrial sector is the largest contributor to CO_2 emissions, with a 47.2% share in 2020, followed by the energy (27.7%) and transport (24.1%) sectors. The share of direct CO_2 emissions from households, which come mainly from liquified petroleum gases (LPG), is small, at 1% in 2020. Enerdata includes emissions from public electricity and heat production and refining under the energy sector. In other words, it attributes electricity use in households to the energy sector, while the industry's own electricity generation (auto producers) is accounted for under the industry sector.

Figure 6. CO_2 emissions from main sectors in Saudi Arabia, 2010–2020.

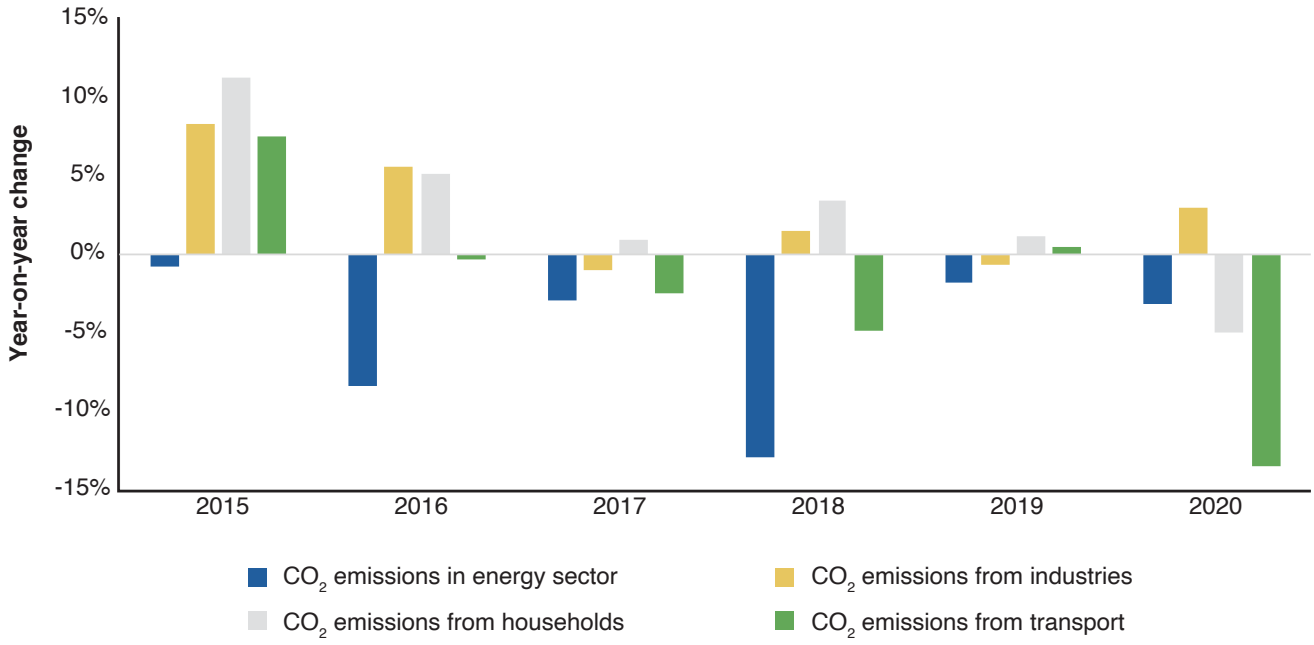


Source: Authors based on Enerdata Global Energy & CO_2 Database.
Based on: Enerdata, IEA, JODI and SAMA.

As Figure 6 shows, the industrial sector's share of emissions has grown increasingly prominent (from 38.9% in 2015 to 47.2% in 2020). The share of energy sector emissions, most of which comes from electricity generation, has diminished (from 33.6% in 2015 to 27.7% in 2020). In absolute terms, Saudi Arabia's CO_2 emissions from fossil fuel combustion in industrial activities have grown by 8.5%, while emissions from the energy sector have decreased by 26.3%.

Figure 7 shows the year-on-year fall in CO_2 emissions in each main economic sector, allowing for a more granular look. The figure focuses on the period from 2015 when Saudi Arabia's total CO_2 emissions appear to have peaked or plateaued. No sustained patterns are evident in any single sector between 2015 and 2020. Emissions fell in all sectors year-on-year in 2020, except in industry, which increased by 2.9%. Furthermore, for the sectors in which emissions fell, the size of the falls varied.

Figure 7. Annual percentage changes in CO_2 emissions from the main sectors in Saudi Arabia, 2015–2020.



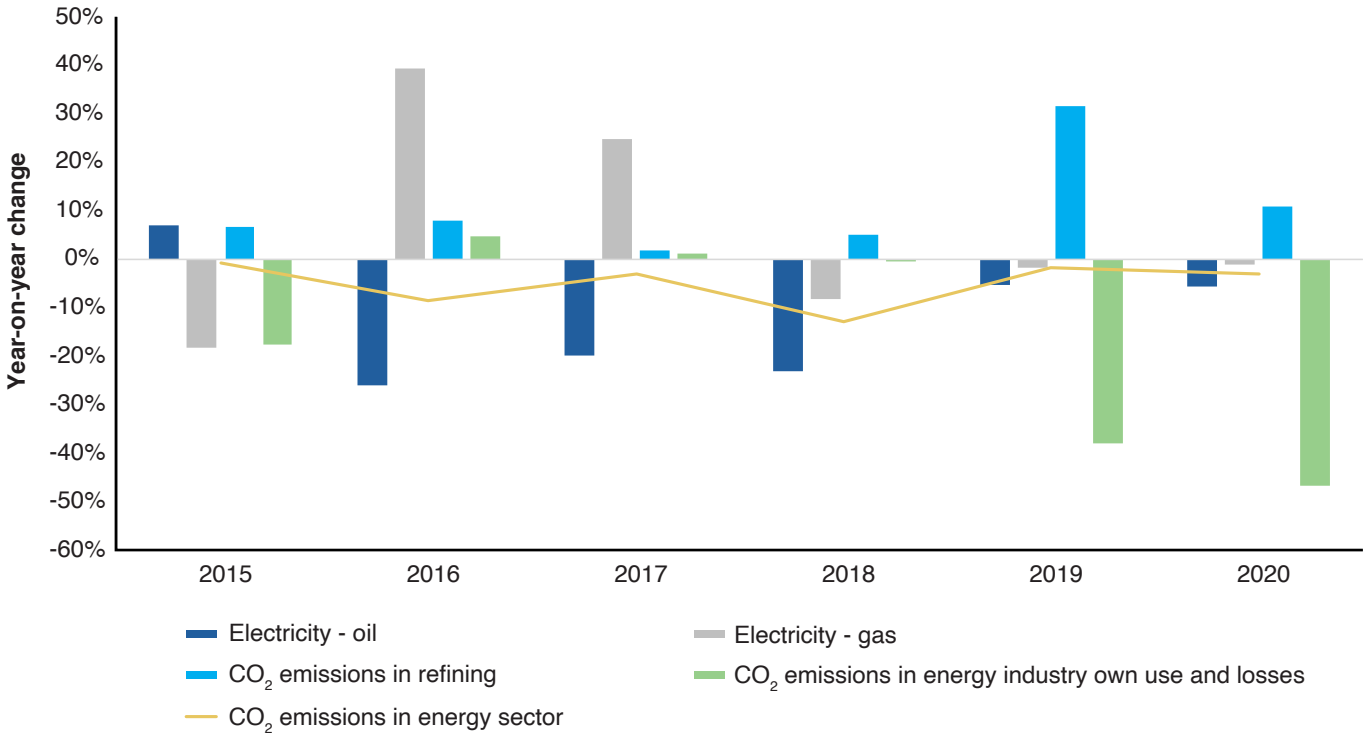
Source: Authors based on Enerdata Global Energy & CO_2 Database.
Based on: Enerdata, IEA, JODI and SAMA.

Transport: In 2020, CO_2 emissions fell most in this sector, which recorded a 13.5% drop. This statistic is not surprising given the extent of the COVID-19 restrictions implemented and their impact on mobility. Road transport accounted for 99.1% of transport-related CO_2 emissions in 2020, with domestic air transport accounting for the rest. Due to pandemic-related movement restrictions, emissions from domestic flights fell by 57.7% compared with 2019 levels. According to Enerdata, reductions in gasoline consumption (which accounts for approximately half of road transport emissions) led to a fall in CO_2 emissions of 12.0 Mt in 2020, compared with 2019.

Households: The second largest year-on-year fall (-4.9%) happened in this sector, which amounted to only 0.25 $MtCO_2$, equivalent to less than 0.1% of total emissions in 2020.

Energy/electricity: Figure 8 provides a more detailed look at emissions in this sector. Since 2015, CO_2 emissions from power generation, which account for approximately 80% of energy sector emissions, have been falling, driven by decreasing emissions from oil-fueled electricity generation. Fuel switching to natural gas took place at the fastest rate between 2016 and 2017, but this appears to have slowed down in 2018. The year 2020 continued the trend of falling overall CO_2 emissions from power generation (-3.3%), while the share of natural gas has remained at slightly over 50% since 2018.

Figure 8. Annual percentage changes in CO_2 emissions from the main sectors in Saudi Arabia, 2015–2020.



Source: Authors based on Enerdata Global Energy & CO_2 Database.
Based on: Enerdata, IEA, JODI and SAMA.

In contrast to the overall declining CO_2 emissions trend in the energy sector, there was a large increase (11.0%) in emissions related to refining. These emissions have consistently increased from 2015 onward due to capacity expansions and upgrades in existing refineries (SASREF, Petro Rabigh, and Saudi Aramco Riyadh refineries), in addition to new refineries coming online (Jazan Refinery). During this period, refining from total energy sector emissions increased from 8.5% to 19.5%. In contrast to the transport sector, however, the share of emissions from the refining sector is a small share of the total fuel combustion CO_2 emissions, i.e., 5.4% in 2020, and thus this increase had less of an impact on total emissions than transportation.

At 0.8% in 2020, emissions from the energy industry's own use and losses are a small share of total energy sector CO_2 emissions. However, there were significant absolute decreases of between 3–4 Mt in these emissions in both 2019 and 2020, which may indicate improvements in the efficiency of energy industry-related industrial processes. Slightly lower crude oil production levels in 2020 also may have played a role.

Industry:[4] For CO_2 emissions from industrial fuel combustion, Enerdata only provides a fuel type breakdown for manufacturing emissions, which account for approximately 90% of emissions in this sector. Here, the shares of the oil and gas-related emissions have remained quite constant since 2016, at around 50% each. However, in absolute terms, emissions have increased throughout the 2010s, and the 2020 growth of 2.9% in industrial emissions seems to have been driven by an increase of 6.0 Mt (6.2%) in oil use in the manufacturing sector.

Emissions trends from auto producers,[5] which Enerdata reports under industrial emissions (unlike some other providers, which report them under energy sector emissions), account for one-third of industrial CO_2 emissions (equal to 15.8% of total CO_2 emissions from fuel combustion in 2020). According to Enerdata, these emissions fell by 2.8% in both 2019 and 2020.

What other data sources say about Saudi Arabia's 2020 CO_2 emissions

Beyond Enerdata, other data sources are relevant in analyzing drivers and changes related to 2020 CO_2 emissions in Saudi Arabia.

Transport: The notable fall in transport sector emissions is easily explained by the pandemic-related movement restrictions. For example, these restrictions caused the demand for gasoline to fall by 16.3% in 2020, according to SAMA (2021). Emissions from this sector are likely to rebound in line with the easing of restrictions and rises in overall economic activity.

Households: Households in Saudi Arabia generally consume electricity, LPG, and small amounts of kerosene and diesel, which are mostly consumed in rural areas (GaStat 2018, 2019, 2020). Electricity accounts for the largest share of residential energy consumption, but the emissions from household electricity use are attributed to the electricity sector. LPG accounts for most of household fuel consumption (GaStat 2018, 2019, 2020), but SAMA (2021) data reveal a 5.3% year-on-year increase in LPG consumption in 2020. Since LPG is used by households for cooking, its increase in 2020 was likely driven by the curfews and the closures of restaurants and cafes during parts of 2020.[6]

Energy/electricity: Based on data from the Saudi Electricity Company (SEC), electricity sales by the SEC declined by 0.8%, from 279.7 terawatthours (TWh) in 2019 to 277.4 TWh in 2020 (SEC 2020, 2021). SEC data appear to corroborate Enerdata's emissions estimates for this sector. In addition to the overall fall in power generation, changes in the fuel mix for power generation also played a role: The SEC reported a fall in fuel costs in its 2020 earnings release due to "diesel displacement [and] lower usage of heavy fuel oil, (…) in line with SEC's strategy of moving towards cleaner sources of energy."[7] SEC (2020, 2021) data also reveal changes in the sectoral breakdown of electricity consumption. For example, the residential sector increased its electricity consumption by 6.5%, likely due to stay-at-home restrictions and travel bans. In contrast, the commercial sector's consumption declined by 12.2% as commercial activities ceased or slowed during the 2020 curfews.

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[4] For the industrial sector, emissions from industrial electricity generation (either for whole or partial own use) are included.
[5] Auto production of electricity is the gross production of auto producers, i.e., companies whose main activities are not electricity production.
[6] It is possible that emissions from the other fuels decreased with changes in urbanization, but it is also possible that Enerdata's estimate for household emissions in 2020 will be revised as newer data become available.
[7] Although the SEC is the largest power producer in the Kingdom, its data do not include electricity sales from other smaller power producers.

Industry: GaStat data reveal that non-oil manufacturing activity fell in every month of 2020 year-on-year, despite Enerdata reporting an increase in emissions in industries. The discrepancy between the GaStat (2021) data and Enerdata estimates suggests there may be either an error in preliminary data, or an increase in the use of more carbon-intensive fuels (such as heavy fuel oil) in the Kingdom's manufacturing industries, unrelated to the pandemic. This latter hypothesis is at least partially supported by the fact that, according to SAMA (2021), the consumption of heavy fuel oil in Saudi Arabia by all sectors increased by 6.5% in 2020. A further possibility is a misallocation of emissions between the industrial and power sectors. However, disaggregated data that would show the percentage changes for industry and power separately are not yet available at the time of writing.

Conclusion

In a year dominated by the COVID-19 pandemic, Saudi Arabia's CO_2 emissions from fuel combustion fell by 3.3% in 2020. Apart from China, which saw its emissions increase in 2020, Saudi Arabia experienced the lowest fall in emissions compared with all other G20 countries, even though the Saudi government implemented and enforced strict measures to tackle the spread of COVID-19 in early 2020.

This Instant Insight has identified several continuities in what drives Saudi Arabia's CO_2 emissions, which are likely to be sustained as the COVID-19 pandemic subsides. At the same time, looking beyond 2021, and in expectation of the rollout of Saudi Arabia's recently launched Circular Carbon Economy National Program, more significant and quicker drops in overall and sectoral emissions over the coming decade can be expected.

About the data

This Instant Insight draws primarily on data downloaded from but not limited to the following source:

- Enerdata Global Energy and CO_2 Database (www.enerdata.net), downloaded June 16, 2021.

Enerdata sources historical information from a range of sources, including the International Energy Agency (IEA), and obtains an estimate for the latest year based on a combination of sources. For example, 2019-2020 data for Saudi Arabia's CO_2 emissions from fuel combustion is based on Enerdata's collation of information from the IEA, the Joint Organisations Data Initiative (JODI), Cedigaz, and the Saudi Arabian Monetary Agency (SAMA). Enerdata updates the values for the latest year at least twice yearly.

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