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King Abdullah Petroleum Studies and Research Center

Saudi Arabia's 2018 CO_2 Emissions Fall Faster Than Expected

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Instant Insight

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January 2020 update to December 03, 2019 Instant Insight (KS--2019-II16)

The Instant Insight published on December 03, 2019 (KS–2019-II16) was based on data downloaded from the following sources:

- Enerdata Global Energy & CO_2 Database (www.enerdata.net), 9 September, 2019
- Enerdata EnerDemand Database (www.enerdata.net), 9 September, 2019
- Joint Organizations Data Initiative (JODI), 9 September 2019

The data used in the previous analysis has been updated by Enerdata, with material revisions to the estimates for 2018 carbon dioxide (CO_2) emissions. Due to media interest in this topic, we have updated our analysis to reflect the most recent information (downloaded January 9, 2020). This has not influenced the general conclusion of the Insight that emissions in Saudi Arabia have fallen significantly for the first time. However, the revised data reveals several important changes regarding the magnitude of the fall both in Saudi Arabia and in other G20 countries. This updated Instant Insight presents this latest view along with extra clarification on the data sources used. In particular it should be noted that Enerdata is used as the primary source of CO_2 data. Enerdata sources historical information (2017 and earlier) from the International Energy Agency (IEA) and obtains an estimate for 2018 CO_2 emissions based on a combination of sources including national statistics and IEA data. For example, 2018 data for Saudi Arabian CO_2 emissions is based on Enerdata's collation of information from the IEA, JODI and the Saudi Arabian Monetary Agency (SAMA). Emissions data on industrial processes is sourced from the United Nations Industrial Development Organization (UNIDO). Enerdata updates the values for the latest year (2018) at least twice yearly. The first update gives preliminary data while the second and any subsequent updates reflect more concrete energy statistics.

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.

This publication is also available in Arabic.

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What has happened?

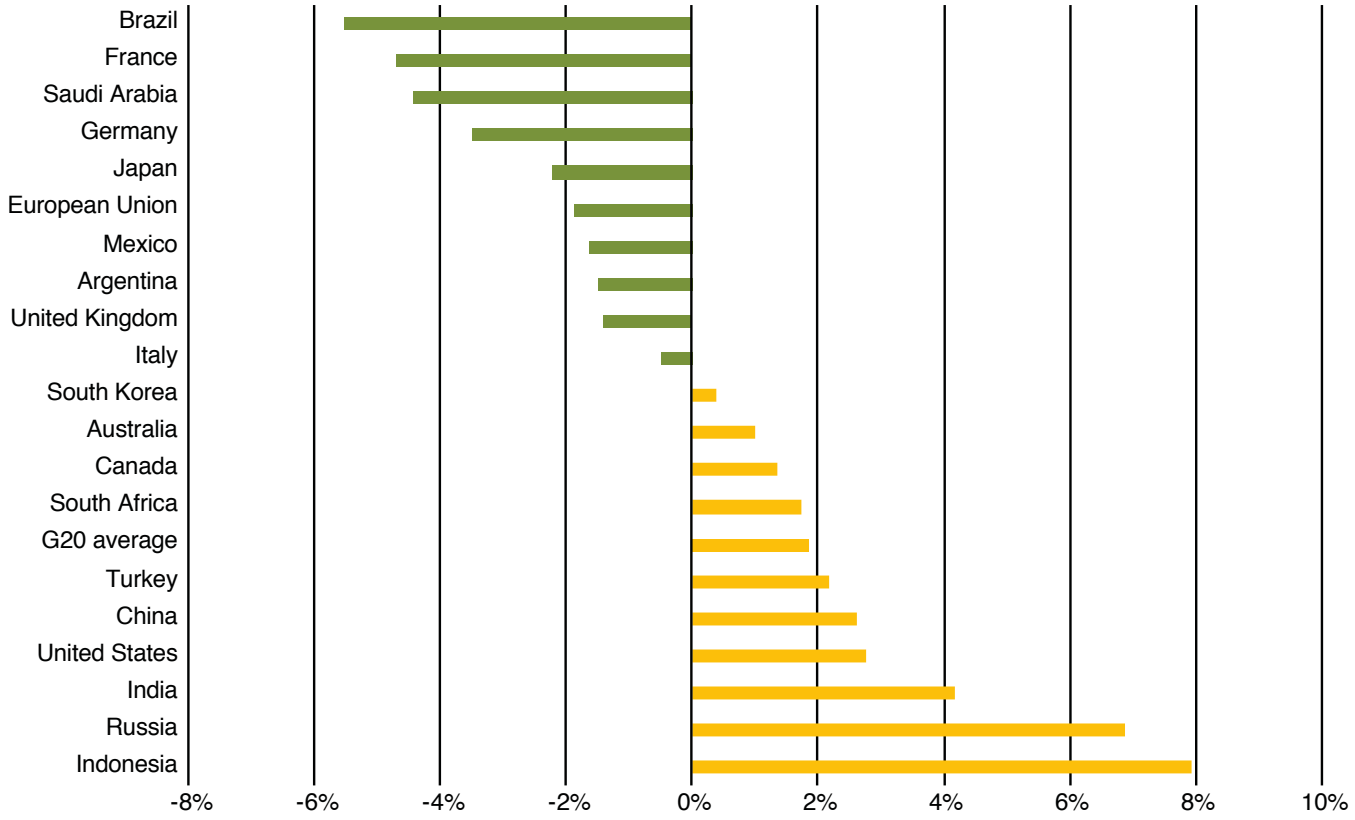
Enerdata has released an update to its 2018 data estimates showing that in 2018 Saudi Arabia's total carbon dioxide (CO_2) emissions fell by 4.4% or 26 million tonnes of CO_2 ($MtCO_2$) from 579 $MtCO_2$ to 553 $MtCO_2$. The previous estimate was a 2.4% reduction (15 $MtCO_2$).

The Kingdom now has moved from being the fourth to the third fastest reducer of greenhouse gasses among the G20 countries for 2018, behind Brazil and France. KAPSARC has updated its analysis to show that the reduction was due to the following factors:

- A stronger fall of 5.48% in the economy's energy intensity, which was responsible for 81% of the reduction in CO_2 emissions.
- A 1.3% fall in the carbon intensity of the energy supply, which was responsible for 19% of the reduction.

Emissions in the transport sector fell by an additional 10 $MtCO_2$ compared with the preliminary estimates, falling by 19% or 23.87 $MtCO_2$ relative to 2017. This was due to a sharp drop in diesel consumption which pushed diesel-related emissions down 43%; a fall of 19 $MtCO_2$ from 43.5 $MtCO_2$ in 2017 to 24.5 $MtCO_2$ in 2018.

Figure 1. Percentage change in CO_2 emissions from fuel consumption 2017-2018.



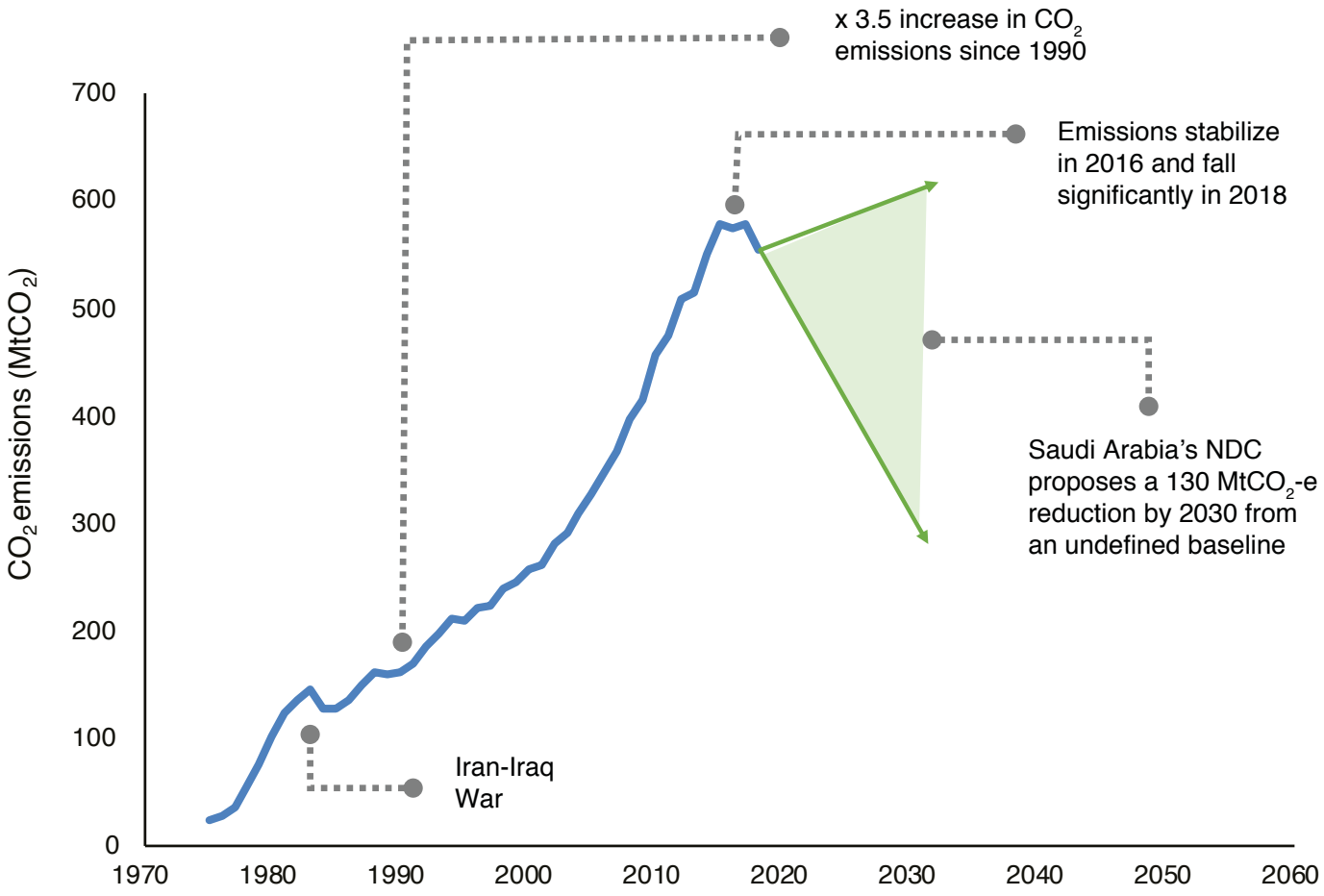
Source: KAPSARC analysis based on Enerdata Global Energy & CO_2 Database (2018) and International Energy Agency (IEA) (2017 and earlier).

Note: G20 comparison based on emissions from fuel consumption, as total CO_2 emissions is not available for all countries.

What is the issue and why does it matter?

The G20 countries account for around 80% of global emissions. The United Nations International Panel on Climate Change (IPCC) "Special Report on Global Warming of 1.5°C" highlighted that "Rapid and far-reaching transitions in energy, land, urban and infrastructure including transport and buildings and industrial systems is needed to achieve climate goals" (IPCC 2018). To stabilize global warming at 1.5 degrees Celsius (°C) above pre-industrial levels, global emissions would need to be carbon neutral by 2050. Saudi Arabia has historically had one of the fastest-growing rates of CO_2 emissions among G20 countries. Saudi Arabia's Vision 2030 is contributing to a 'green transition' through its policies on economic diversification, energy efficiency, domestic energy price reform and fuel mix changes, such as the increased use of natural gas. The country's adoption of renewable and nuclear energy offers the potential for a further 'greening' of its economic growth.

Figure 2. Saudi Arabia's historical emissions and possible CO_2 pathways.



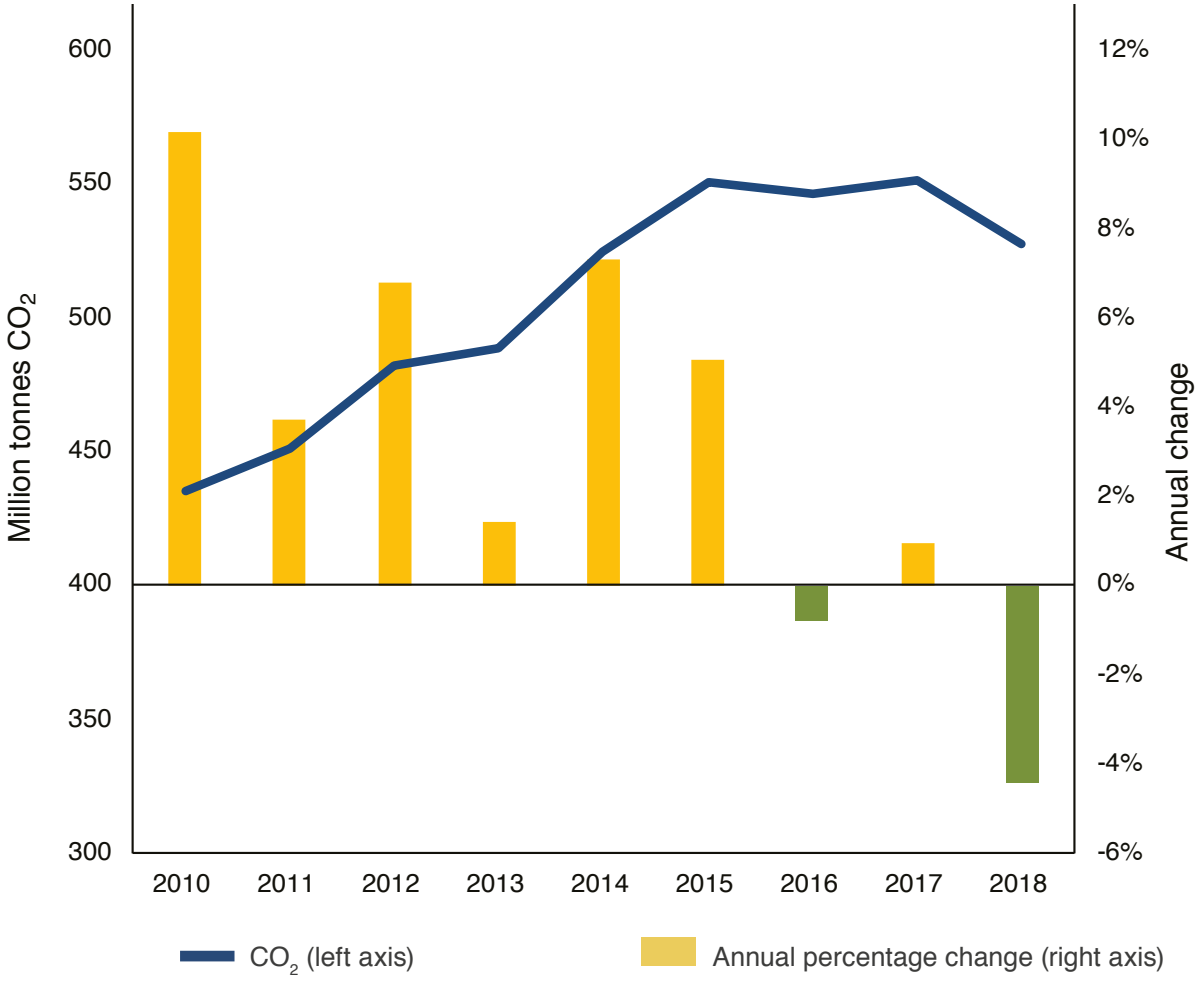
Source: KAPSARC analysis based on Enerdata Global Energy & CO_2 Database (2018 data) and IEA (2017 and earlier).

Note: Data series relates to total CO_2 emissions without land use, land-use change and forestry (LULUCF), in CO_2 equivalent. For Saudi Arabia, this is the sum of CO_2 emissions from fuel combustion and CO_2 emissions from industrial processes such as cement manufacturing.

What is behind the fall in the Kingdom's emissions?

The Kingdom's historically fast pace of emissions growth has been slowing, falling from a peak of around 10% per annum in 2010 to around 5% between 2011 and 2015. It stabilized in 2016 and 2017 and fell by 4.4% in 2018. This raises the question, What is behind this fall?

Figure 3. Saudi Arabia's CO_2 emissions from fuel combustion (2010-2018).



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

The Kaya identity is a common means of assessing the reasons for changes in CO_2 emissions at the economy-wide level. This is an expression stating that total CO_2 emissions can be described as the product of four factors: carbon intensity (emissions per unit of energy consumed), energy intensity (energy per unit of gross domestic product [GDP]), economic activity (GDP per capita) and population.

Equation 1: The Kaya identity.

$$CO_2 = \frac{CO_2}{TPEC} * \frac{\text{TPEC}}{GDP} * \frac{\text{GDP}}{POP} * POP$$

Where:

- CO_2 is carbon emissions from human activities
- 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.

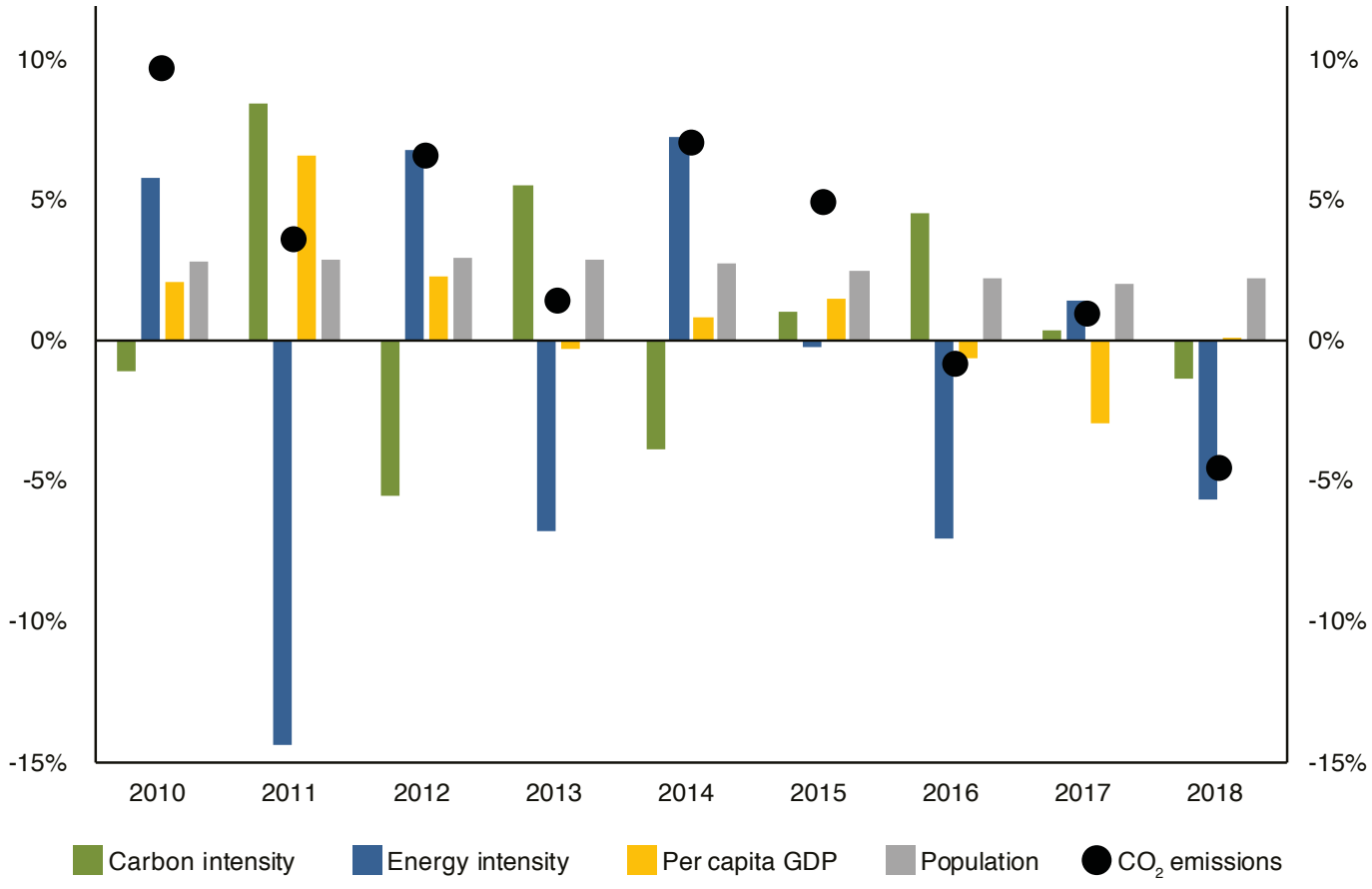
Differentiating Equation 1 provides the change in total emissions as a result of each of these factors for a given year (Equation 2).

Equation 2: Change in CO_2 emissions according to the Kaya identity.

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

Figure 4 visualizes Equation 2:

Figure 4. Drivers of change in annual CO_2 emissions (2010-2018).



Source: KAPSARC analysis based on Enerdata Global Energy & CO_2 Database (2018 CO_2, TPEC) IEA (2017 and earlier CO_2, TPEC), World Bank (Population, GDP 2015 constant purchasing power parity terms).

The Kaya identity analysis in Figure 4 suggests that the fall of 4.4% in 2018 CO_2 emissions was driven by two major factors. The prime driver was a fall in the economy's energy intensity in 2018 of 5.48% compared with the year before. This reflects increasing levels of energy efficiency in the economy and a less energy intensive economic structure, enabled by economic diversification (KAPSARC-UNESCWA 2017). A secondary factor was a fall of 1.3% between 2017 and 2018 in the carbon intensity of the energy supply. Per capita GDP was stable in 2018 and did not significantly influence emissions, while population growth was steady at 2.3% and placed upward pressure on CO_2 emissions.

In previous years, improvements in the energy intensity of the economy were offset by increases in the carbon intensity of the country's energy supply, slowing Saudi Arabia's CO_2 emissions reduction. In 2018, the energy intensity of the economy and the carbon intensity of the country's energy supply fell simultaneously for the first time, enabling the first significant fall in Saudi Arabia's CO_2 emissions. Another factor influencing the Kingdom's CO_2 emissions in the last few years has been the slowing growth of per capita incomes, which averaged 2.2% between 2010 and 2015. The decline in per capita GDP of 0.6% and 2.9% in 2016 and 2017 was a major factor behind the initial stabilization of CO_2 emissions growth. Per capita GDP stabilized in 2018, rising by 0.14% and thus having no significant effect on CO_2 emissions.

In which sectors of the economy did emissions fall?

Another way to assess Saudi Arabia's emissions profile is to consider the CO_2 emissions of its main energy consuming sectors (Figures 5 and 6). This shows that before 2016, emissions growth averaged about 5% across all CO_2 emitting sectors. Since 2016, emissions have stabilized across all sectors, with emissions from transport falling by 19% (23.87 $MtCO_2$) in 2018. This fall in transport-related emissions is significantly higher than earlier estimates which suggested a 10% decline in transport emissions (13.15 $MtCO_2$).

Saudi Arabia's transportation sector accounts for around 21% of the country's total energy consumption, or approximately 1 million barrels of oil equivalent per day (SEECa 2018). According to Enerdata, transportation emissions from road, rail and domestic aviation amounted to 100 $MtCO_2$ in 2018. Road transport accounts for 95% of all the Kingdom's emissions and is split between vehicles using gasoline (69% of total transport fuel consumed) and diesel (31% of total transport fuel consumed). Light-duty vehicles account for 52% and heavy-duty vehicles for 40% of the country's vehicle fleet (SEECa 2018b).

The majority of emission reductions have come from a strong decline in transport-related diesel consumption, which fell by 19 $MtCO_2$ or 43.53%, from 43.5 $MtCO_2$ in 2017 to 24.5 $MtCO_2$ in 2018. The fall in diesel emissions is around 10 $MtCO_2$ greater than the 9 $MtCO_2$, or 20% reduction, previously estimated by Enerdata. Gasoline emissions fell by 4.9 $MtCO_2$, or 6.5%, from 75.8 $MtCO_2$ in 2017 to 70.9 $MtCO_2$ in 2018 (Figure 7), consistent with previous estimates.

Figure 5. Saudi Arabia's sectoral CO_2 emissions (2010-2018).

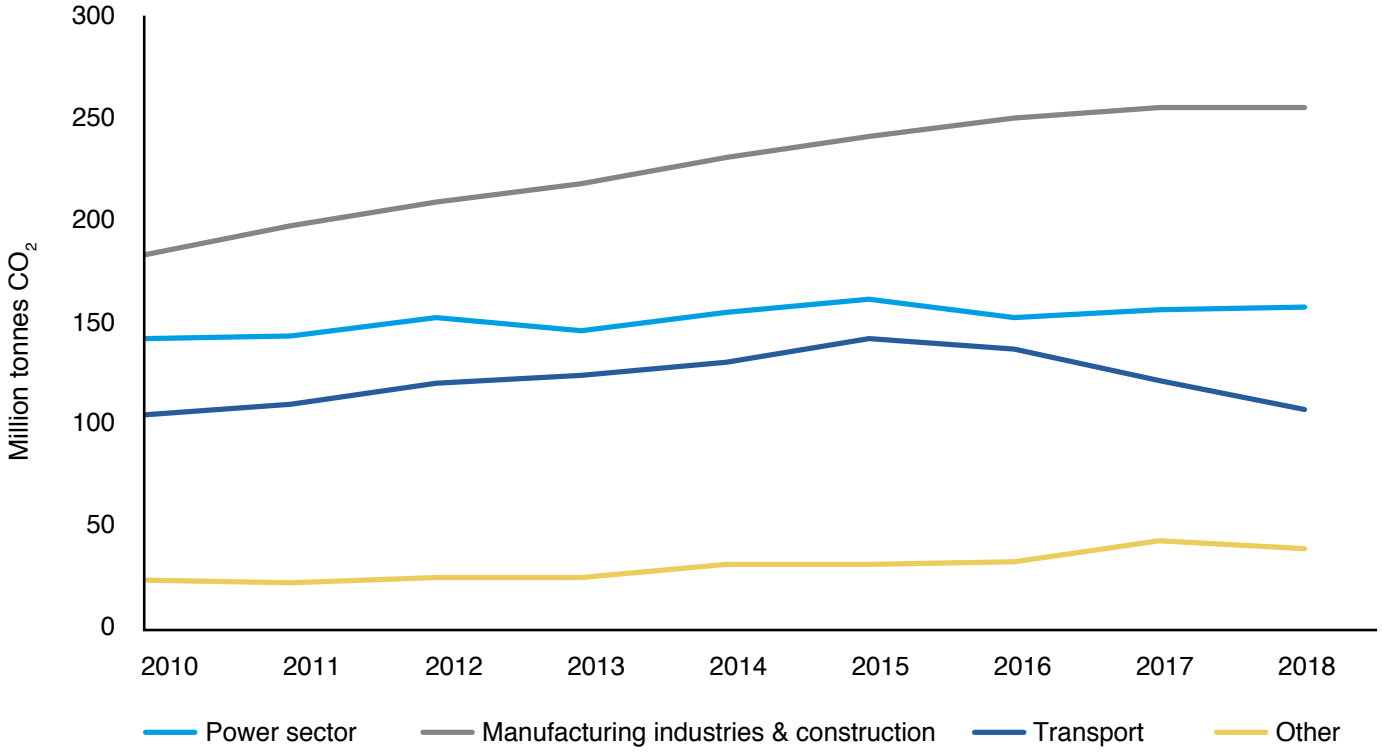
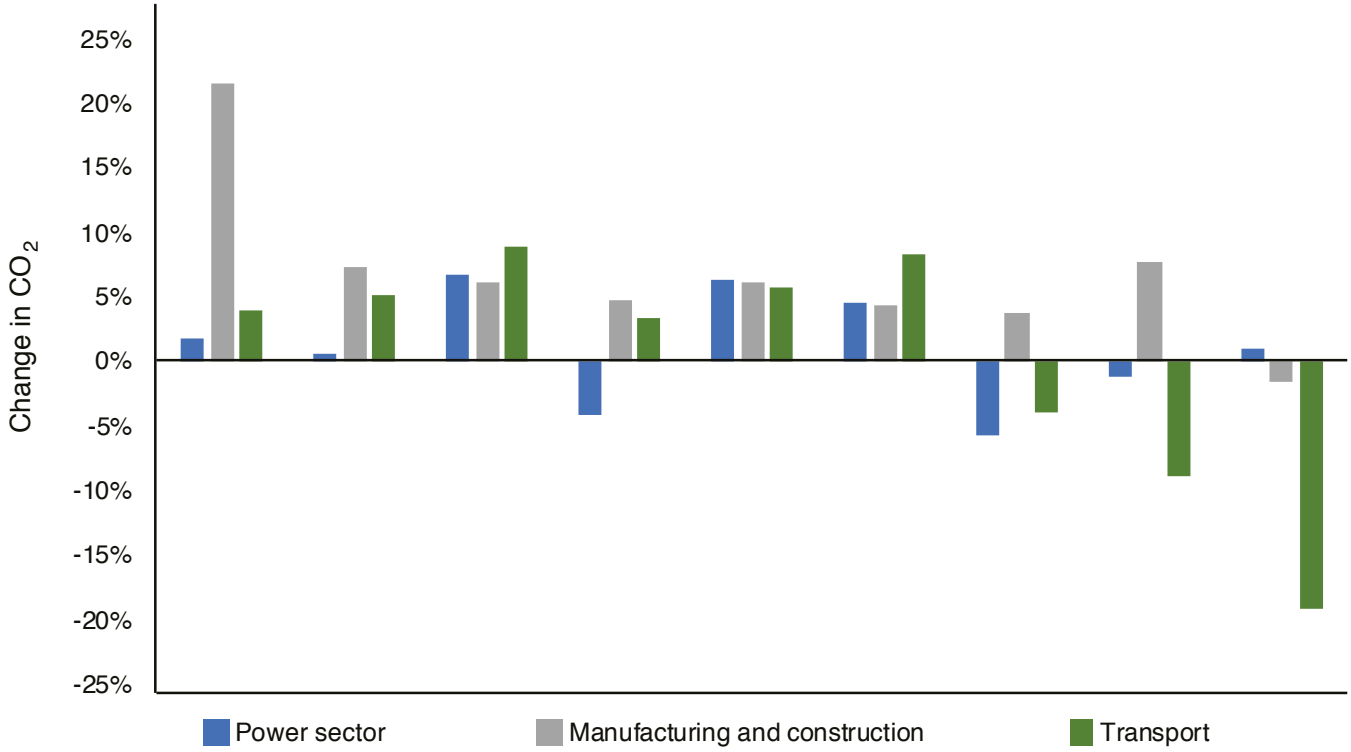


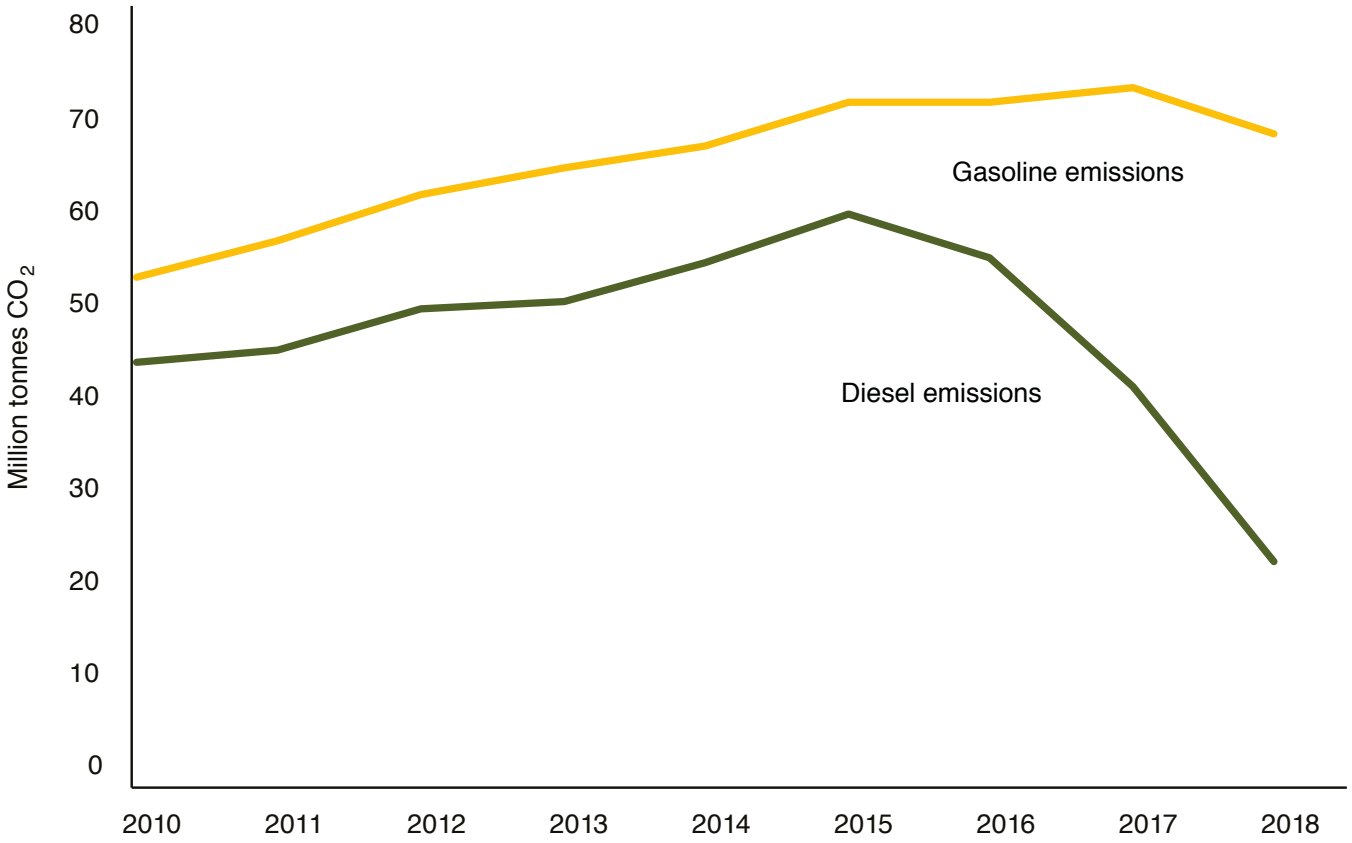
Figure 6. Percentage change in CO_2 for major sectors in Saudi Arabia (year-on-year).



Source for Figures 5 & 6: KAPSARC analysis based on Enerdata CO_2 balance for Saudi Arabia (sectoral approach), UNIDO (industrial processes).

Note: Manufacturing and construction includes industrial process emissions. 'Other' includes refining, agriculture, and residential energy use excluding electricity (power).

Figure 7. CO_2 emissions from gasoline and diesel used in transport (2010-2018).



Source: KAPSARC analysis based on Enerdata EnerDemand Database (gasoline and diesel fuel consumption).
Note: Standard emissions factors are used, using the EECA (2019) conversion tool.

The industrial sector in Saudi Arabia consumes 2.1 million barrels of oil equivalent per day, around 44% of the Kingdom's total energy consumption (SEECa 2018). Enerdata's updated figures for 2018 suggest industrial emissions in the manufacturing and construction sector from fuel combustion accounted for 238 $MtCO_2$. Enerdata sources information on industrial emissions from chemical processes that release CO_2 from UNIDO. These emissions stood at 27 $MtCO_2$ in 2015, 2016 and 2017. For Figure 5 we assume these emissions remain at this level, as UNIDO is yet to release 2018 data. The three main industrial sectors, petrochemicals, cement and steel production, account for around 38%, 21% and 11% of total industrial energy consumption, respectively (SEECa 2018).

Buildings are the second largest consumer of energy in the Kingdom, accounting for around 29% of all energy consumed, or 1.4 million barrels of oil equivalent per day (SEEC 2018a). Power demand is dominated by electricity demand from buildings, with residential buildings accounting for around 51% of the Kingdom's total final electricity demand, followed by 35% for buildings in the commercial and service sectors.

What was behind the improvements in the energy efficiency of the economy?

Two main drivers are working together to bring about improvements in energy efficiency: stronger energy efficiency regulations and energy price reform.

Energy efficiency regulations

The Kingdom has around 80 energy efficiency initiatives, supported by 13 teams targeting Saudi Arabia's major energy consuming sectors. The Saudi Energy Efficiency Center (SEEC) and its implementation of the Saudi Energy Efficiency Program (SEEP) have facilitated these initiatives. SEEP has focused on the three main energy consuming sectors (industry, buildings and transportation), which account for over 90% of the country's energy consumption. The initiatives have been supported by major communications drives across social media platforms, including Twitter, YouTube and Instagram, as well as more traditional media such as television, radio, newspapers and billboards. The government's increased enforcement activities, in partnership with the Saudi Electrical Company (SEC), mean no new buildings can be connected to the grid unless they comply with the Saudi buildings code pertaining to categories such as thermal insulation and air leakage. Supported by the Ministry of Commerce, over 37,000 inspections have been carried out, 5,000 infractions have been issued, 2.1 million non-compliant products such as air conditioners have been confiscated, and 75 non-compliant factories have been closed.

Transport

Fuel economy performance requirements were set for all incoming light-duty vehicles (LDV) in 2016, and they have led to a 10% improvement in the fuel economy of the new fleet. All new cars require fuel efficiency labels, with labels having also been created for battery electric vehicles and plug-in hybrid electric vehicles. Any used vehicle that falls below the minimum energy performance standard is also banned from import. The SEEC's LDV tire rolling resistance program is also expected to reduce fuel consumption by 2%-4%.

The government has introduced several energy efficiency standards to enhance the efficiency of heavy-duty vehicles (HDVs). These include a fuel efficiency improvement program, and a fuel efficiency labeling and tire resistance and grip initiative. An HDV aerodynamic initiative started in 2019 and is scheduled to be implemented in 2021. This initiative is expected to achieve fuel savings of 5%-9%.

Industry

The SEEC has helped reduce the energy intensity of the petrochemical, cement and steel sectors by around 7.1% through its energy efficiency framework for industrial plants. From 2010-2019, the industrial sector had an overall target to improve energy intensity by around 9%, or 1% per year. An agreement with the Saudi Industrial Development Fund to provide soft loans for energy efficiency-related projects was an important enabler of this reduction.

Buildings

Cooling is the major driver of buildings emissions, accounting for 70% of household and commercial sector electricity consumption. The SEEC has introduced stronger building codes for high and low rise buildings. There are 14 insulation standards covering air conditioning (AC) units. The SEEC has also substantially increased its energy efficiency rating (EER) requirements for AC units. The EER required for split units, for example, increased from 7.5 to 11.8 between 2012 and 2018. It has also introduced a consumer rebate of 900 Saudi riyals (SAR) per unit for up to six units per household, to increase the market penetration of ACs that exceed these minimum requirements.

Energy efficiency standards are also in place for refrigerators and freezers, washing machines, water heaters, clothes dryers and lighting products. In 2018, the SEEC received a new mandate to incorporate energy efficiency in power generation, electricity transmission and distribution, and water desalination.

Energy pricing

The government began to reform energy prices in 2016 (Table 1) to reduce wasteful energy use and diversify the sources of government revenue. This was motivated by the government's wish to move from a system of energy pricing based on a very low cost of fuel production toward international benchmarks. To help cushion the impact of this and other economic reforms, in January 2018 the government introduced a means tested system of direct payments through its Citizens Account Program. As of April 2019, 17 monthly payments had been made, amounting to 40 billion SAR (US$ 10.7 billion).

Table 1. Saudi Arabia's energy price reforms.

	2015		2016		2018		2015-2018	
Gasoline (95) US$/L	0.16		0.24		0.54		+238%	
Gasoline (91) US$/L	0.12		0.20		0.37		+208%	
Natural gas ($/MMbtu)	0.75		1.25		1.25		+66%	
Ethane ($/MMbtu)	0.75		1.75		1.75		+133%	
Diesel for industry (US$/barrel)	9.11		14.1		16.15		+77%	
Arab light crude (US$/barrel)	4.24		6.35		6.35		+50%	
Arab heavy crude (US$/barrel)	2.67		4.4		4.4		+65%	
Electricity for industry (US$/kWh)	0.037		0.048		0.048		+30%	
Electricity for households (US$/kWh)	< 6,000 <		< 6,000 <		< 6,000 <		< 6,000 <	
	0.02	0.06	0.03	0.08	0.048	0.08	+140%	+33%

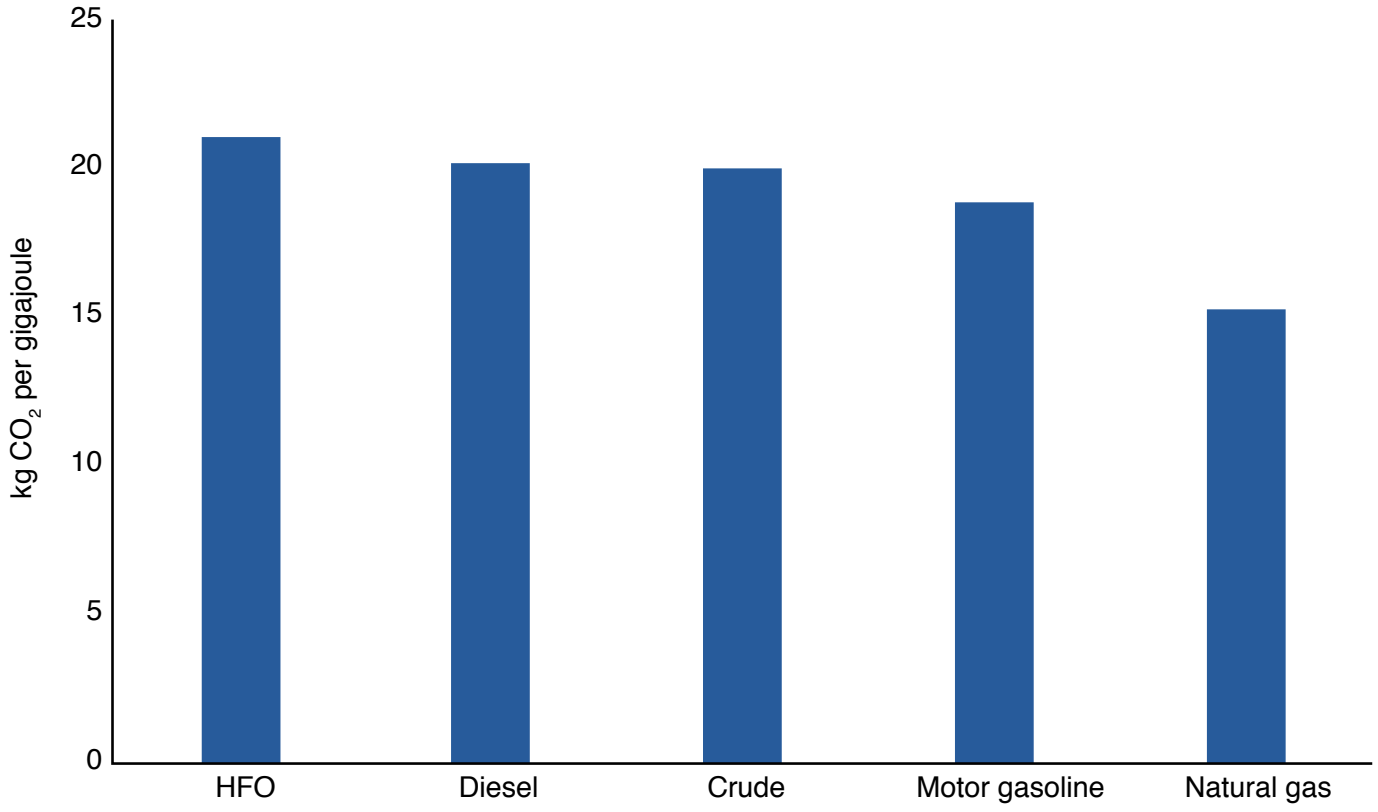
Sources: KAPSARC analysis based on Saudi Electricity Company and APICORP data; Al Dubyan and Gasim (2018).

The transportation sector has seen the largest increase in energy prices in percentage terms, tripling compared with 2015 levels. In addition, from the start of 2019, the government began making small quarterly adjustments to transport fuels to take into account changes in international oil prices (Dubyan and Gasim 2019). For example, the price of 91 and 95 octane gasoline in September 2019 was US$ 0.37 and US$ 0.58, respectively. The other energy prices in Table 1 have remained at 2018 levels. The energy price reform process remains ongoing, with further increases expected.

What was behind the fall in the economy's carbon intensity?

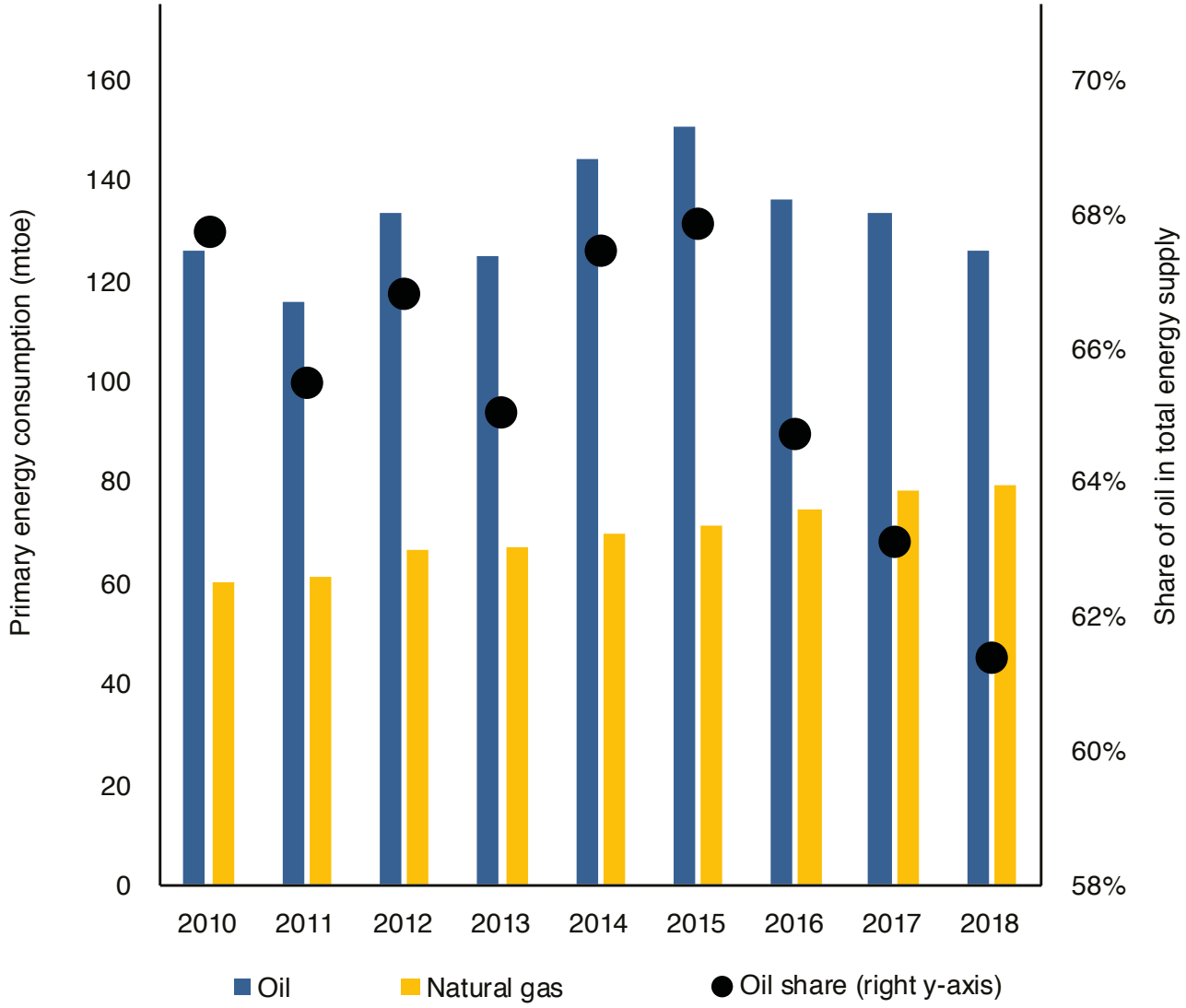
Different fuels have varying levels of CO_2 emissions intensity for a given energy content (Figure 8). For example, using natural gas emits around 25% less CO_2 emissions than using oil to produce the same amount of energy. This is significant as the share of oil used in the primary energy supply in Saudi Arabia has fallen from 150 Mtoe, or 68%, in 2015 to 125 Mtoe, or 61%, in 2018. Meanwhile, the share of natural gas has risen from 71 Mtoe, or 32%, in 2015 to 79 Mtoe, or 39%, in 2018 (Figure 9). From 2010-2018, the production of domestic natural gas grew by an average of 3.6% per year.

Figure 8. CO_2 content of the main fuels used in Saudi Arabia.



Source: IEA (2017).
Note: HFO = heavy fuel oil.

Figure 9. Share of primary energy sources in Saudi Arabia's domestic energy supply.

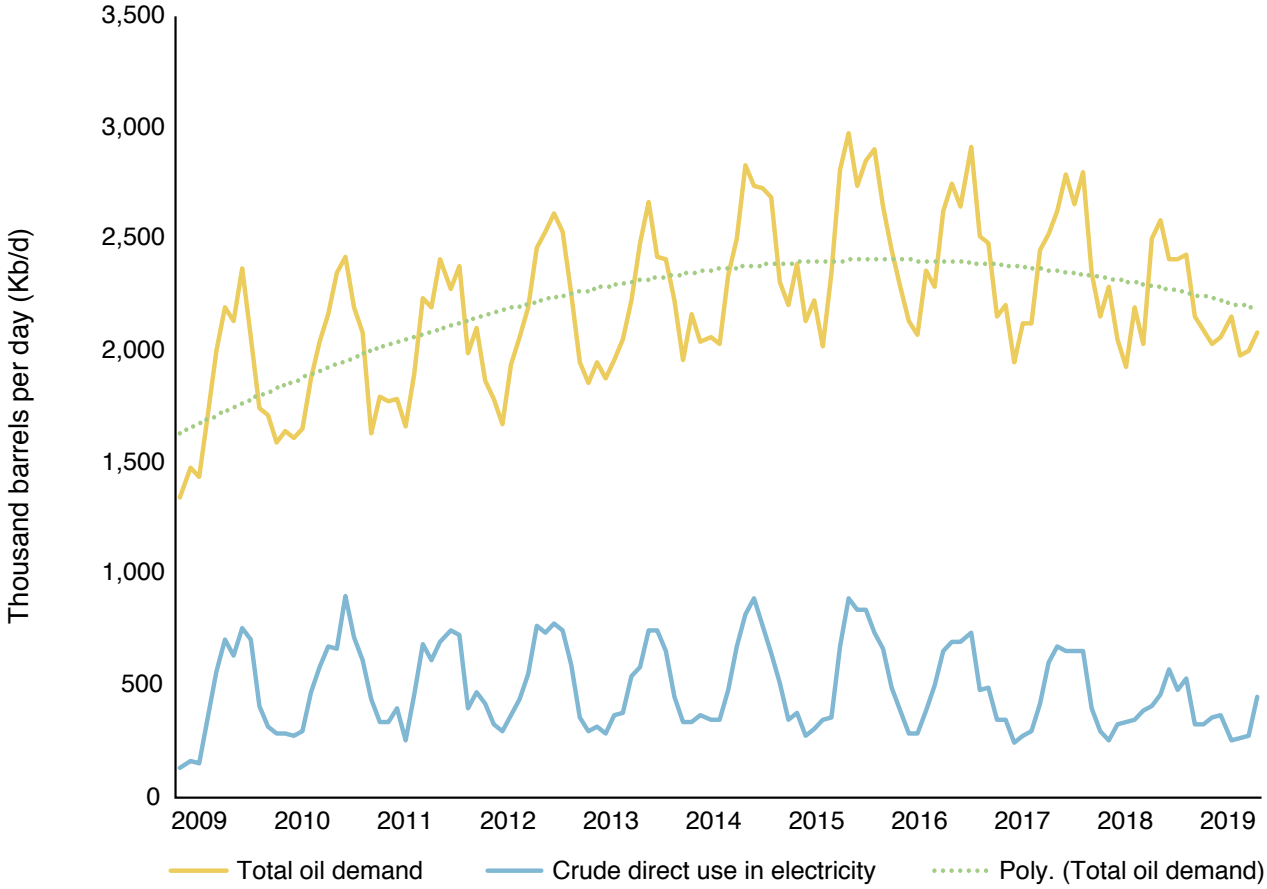


Source: KAPSARC analysis based on Enerdata Global Energy & CO_2 Database (2018) and IEA (2017 and earlier).

The decline in the share of oil in Saudi Arabia's fuel mix is evident in the Kingdom's monthly consumption of oil published on the Joint Organizations Data Initiative (JODI) platform. Figure 10 shows the domestic consumption of oil peaking during the summer of 2015 at 2.984 million barrels of oil per day (MMb/d), falling to a lower inter-annual annual peak in 2018 of 2.596 MMb/d.

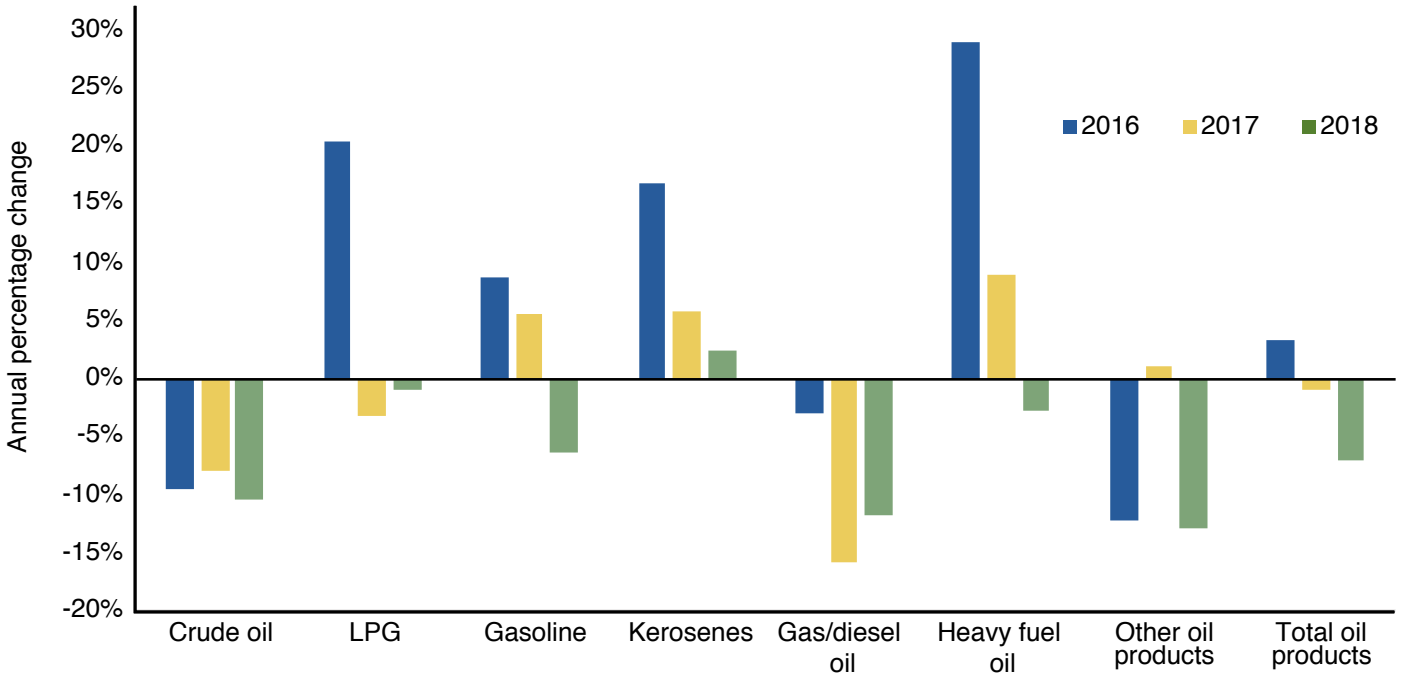
Figure 11 illustrates the annual change in total oil products consumption for 2016-2018. It shows a significant reduction (around 10% each year) in the amount of crude oil being burned for electricity generation, and a reduction in diesel consumption of around 15% in 2017 and 12% in 2018. Increases in the consumption of heavy fuel oil (in 2016 and 2017), liquefied petroleum gas (in 2016) and gasoline (in 2016 and 2017) offset these declines. It is significant that in 2018, all major categories of domestic oil consumption declined (except kerosene), leading to an overall decline in total oil products consumed of 7%.

Figure 10. Saudi Arabian total oil products consumption (2009-2019).



Source: KAPSARC analysis based on JODI data.

Figure 11. Saudi Arabian total oil products consumption (annual change, 2016-2018).



Source: KAPSARC analysis based on JODI data.

Note: LPG = liquefied petroleum gas; HFO = heavy fuel oil.

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