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King Abdullah Petroleum Studies and Research Center

What is Behind the Recent Fall in Saudi Arabia's 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 and why is it significant?

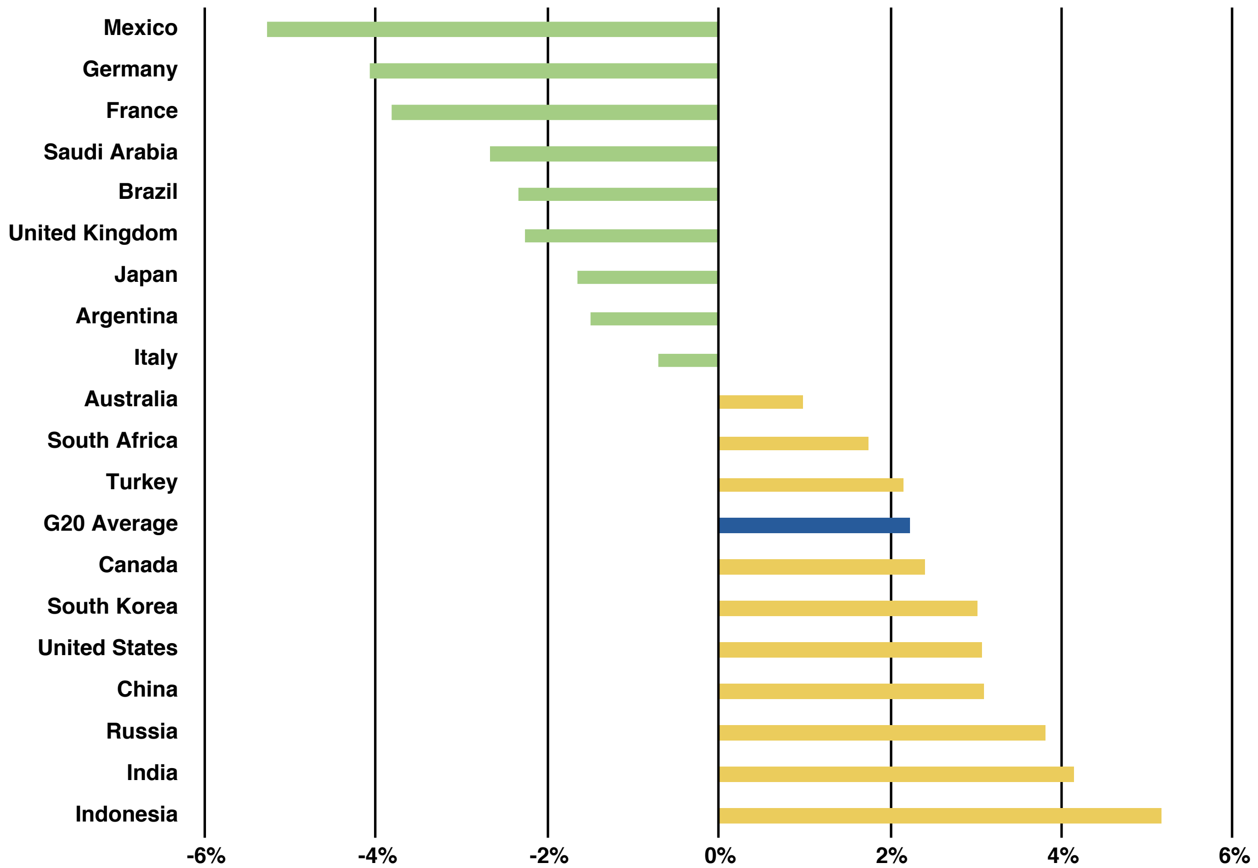
Enerdata has recently released data showing that in 2018 Saudi Arabia's carbon dioxide (CO_2) emissions fell by 15 million tonnes of CO_2 ($MtCO_2$), or 2.7%, from 577 $MtCO_2$ to 562 $MtCO_2$. This is significant as it is Saudi Arabia's first large policy-induced reduction in CO_2 emissions. It also highlights how Saudi Vision 2030's economic transformation plans are helping to decouple its economic growth from its CO_2 emissions. The Kingdom is now the fourth-fastest reducer of greenhouse gasses among the G20 group of countries.

KAPSARC research suggests that the reduction in emissions was due to two main factors:

- improvements in the energy intensity of the economy, which were responsible for 74% of the reduction;
- and a fall in the carbon intensity of Saudi Arabia's energy supply, which was responsible for 26% of the emissions reduction.

In 2018, Saudi Arabia's emissions were stable or declining in all energy consuming sectors of the economy, with transport delivering the majority of the reductions, falling by 13.25 $MtCO_2$ or 11% compared with the year before. The share of natural gas in the fuel mix, which is 25% less carbon intensive than oil, has risen from 32% in 2015 to 38% in 2018.

Figure 1. Percentage change in CO_2 emissions (2017-2018).

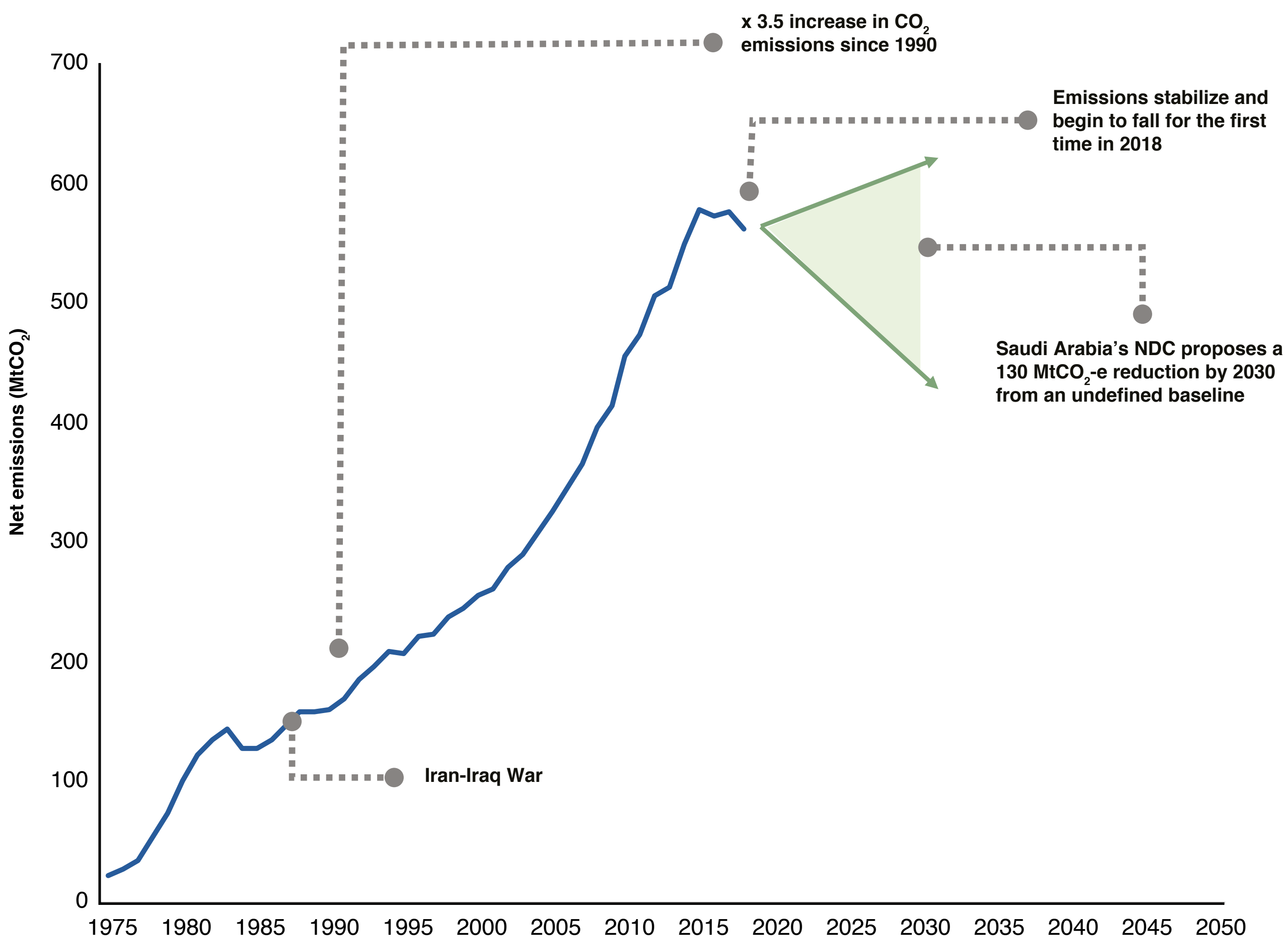


Source: KAPSARC analysis based on Enerdata (2018), and International Energy Agency (IEA) (2017 and earlier).
Note: data accessed on the 9th of September 2019.

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 carbon dioxide (CO_2) pathways.

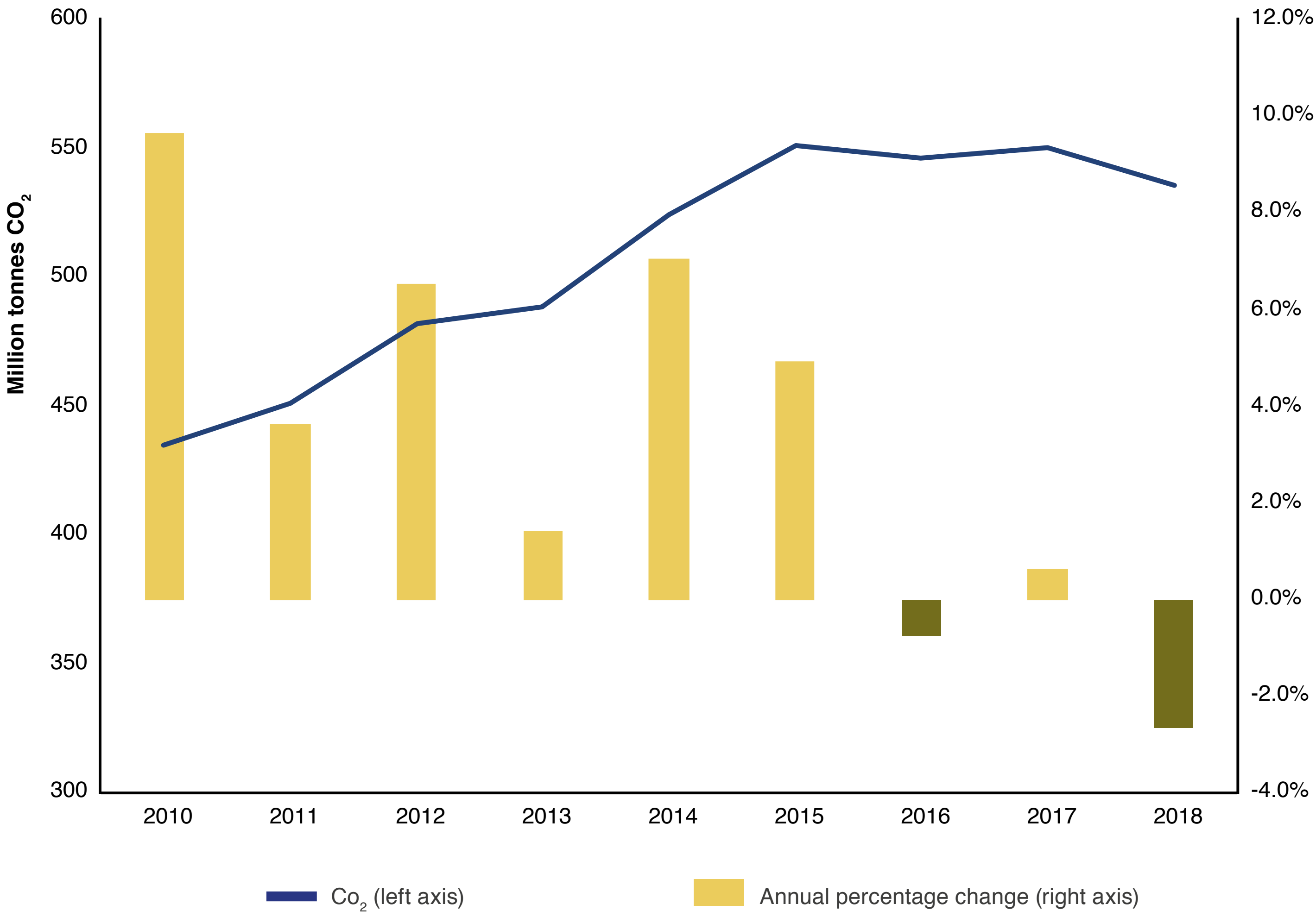


Source: KAPSARC analysis based on Enerdata (2018), and International Energy Agency (IEA) (2017 and earlier).
Note: data accessed on the 9th of September 2019.

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

Since 2010, 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 2.7% in 2018. This raises the question, What is behind this fall?

Figure 3. Saudi Arabia's CO_2 emissions and annual percentage change (2010-2018).



Source: KAPSARC analysis based on Enerdata (2018), and International Energy Agency (IEA) (2017 and earlier).
Note: data accessed on the 9th of September 2019.

The Kaya identity is a common means of assessing the reasons for changes in CO2 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.

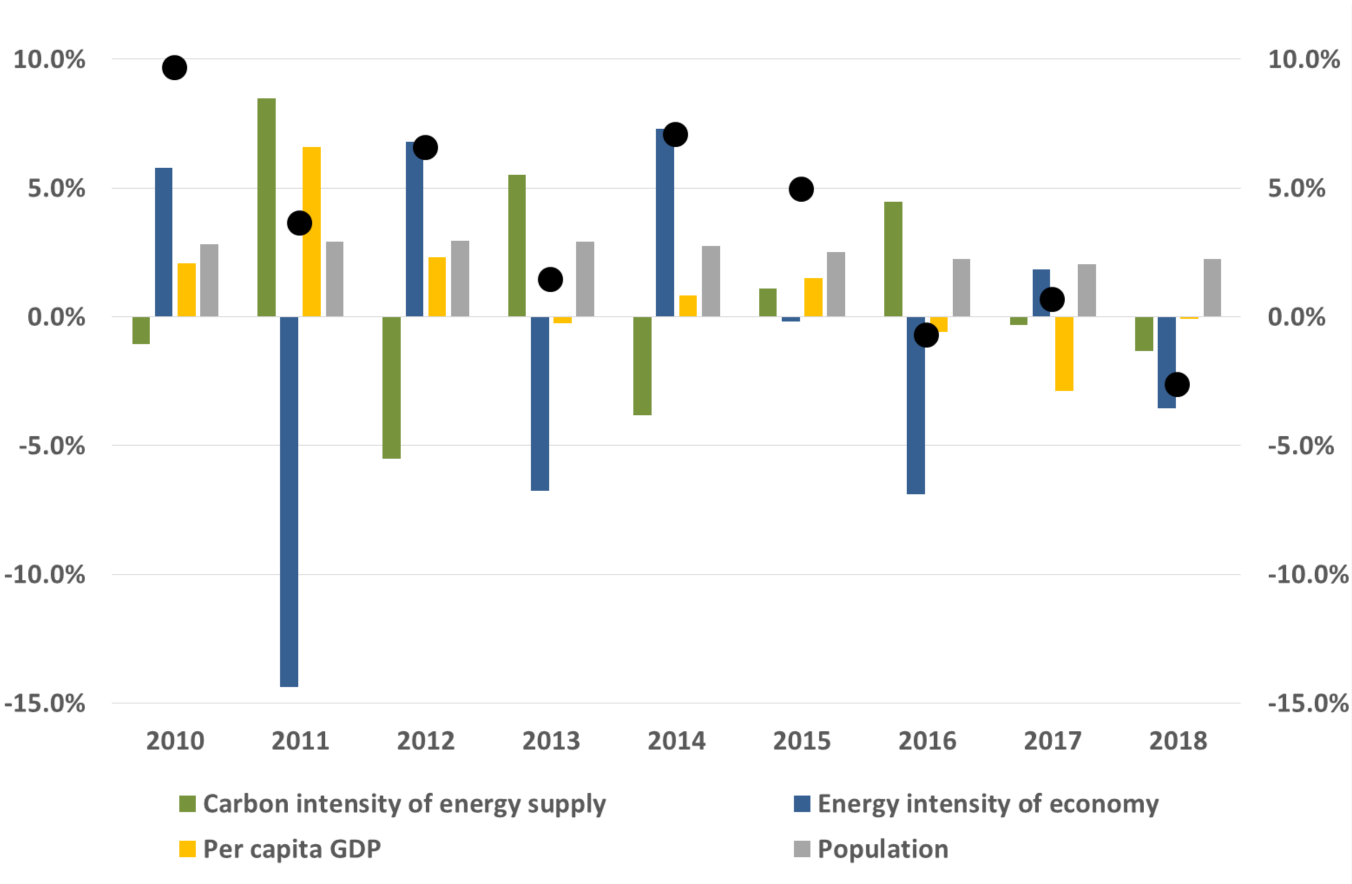
Differentiating Equation 1 provides the change in total emissions as a result of each of these factors for a given year (Equation 2).

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 using IEA data for energy consumption and CO_2 emissions and World Bank data for GDP and population, collated by the service provider Enerdata.

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



Source: KAPSARC analysis based on Enerdata (2018 CO_2, TPEC) IEA (2017 and earlier CO2, TPEC), World Bank (Population, GDP 2015 constant purchasing power parity terms).
Note: data accessed on the 9th of September 2019.

The Kaya identity analysis in Figure 4 suggests that the fall of 2.7% in in 2018 CO_2 emissions was driven by two major factors. The prime driver was a fall in the economy's energy intensity of 3.5%. 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% 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.

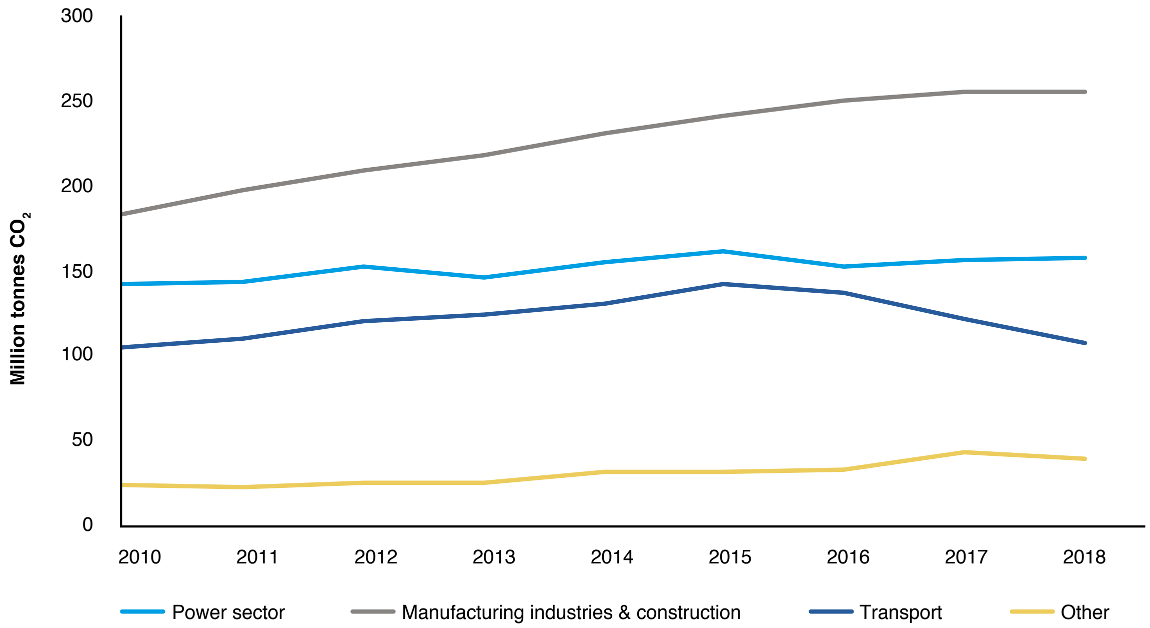
In previous years, improvements in the energy intensity of the economy were offset by increases in the carbon intensity of the country's energy supply, slowing Saudi Arabia's CO_2 emissions reduction. In 2018, the energy intensity of the economy and the carbon intensity of the country's energy supply 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, falling only 0.1% and thus having no effect on CO_2 emissions.

In which sectors of the economy did emissions fall?

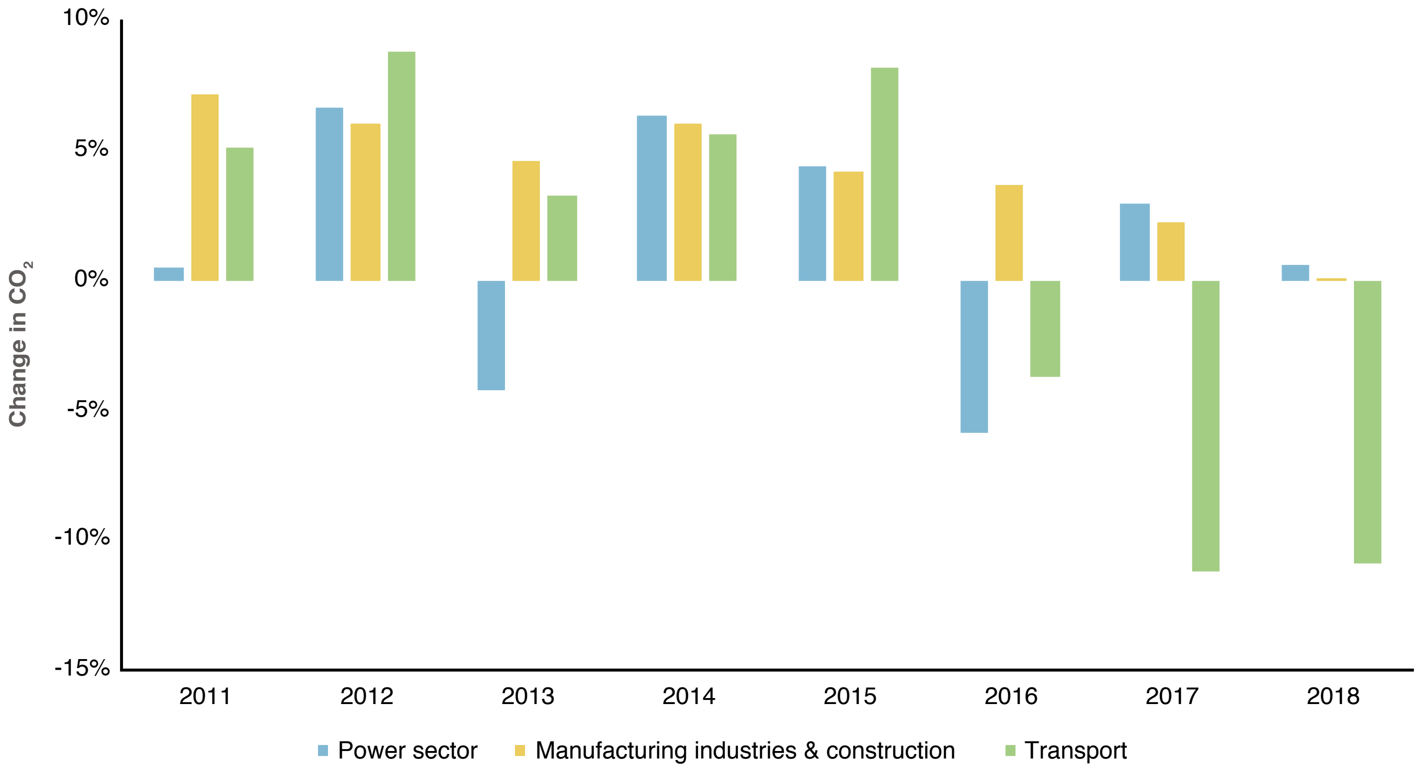
Another way to assess Saudi Arabia's emissions profile is to consider the CO_2 emissions of its main energy consuming sectors (figures 5 and 6). This shows that before 2016, emissions growth averaged about 5% across all CO_2 emitting sectors. Since 2016, emissions have stabilized across all sectors, with a fall of over 10% (13.15 $MtCO_2$) from transport in 2018.

Figure 5. CO_2 emissions from Saudi Arabia's main energy consuming sectors (2010-2018).



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



Source: KAPSARC analysis based on Enerdata CO2 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).

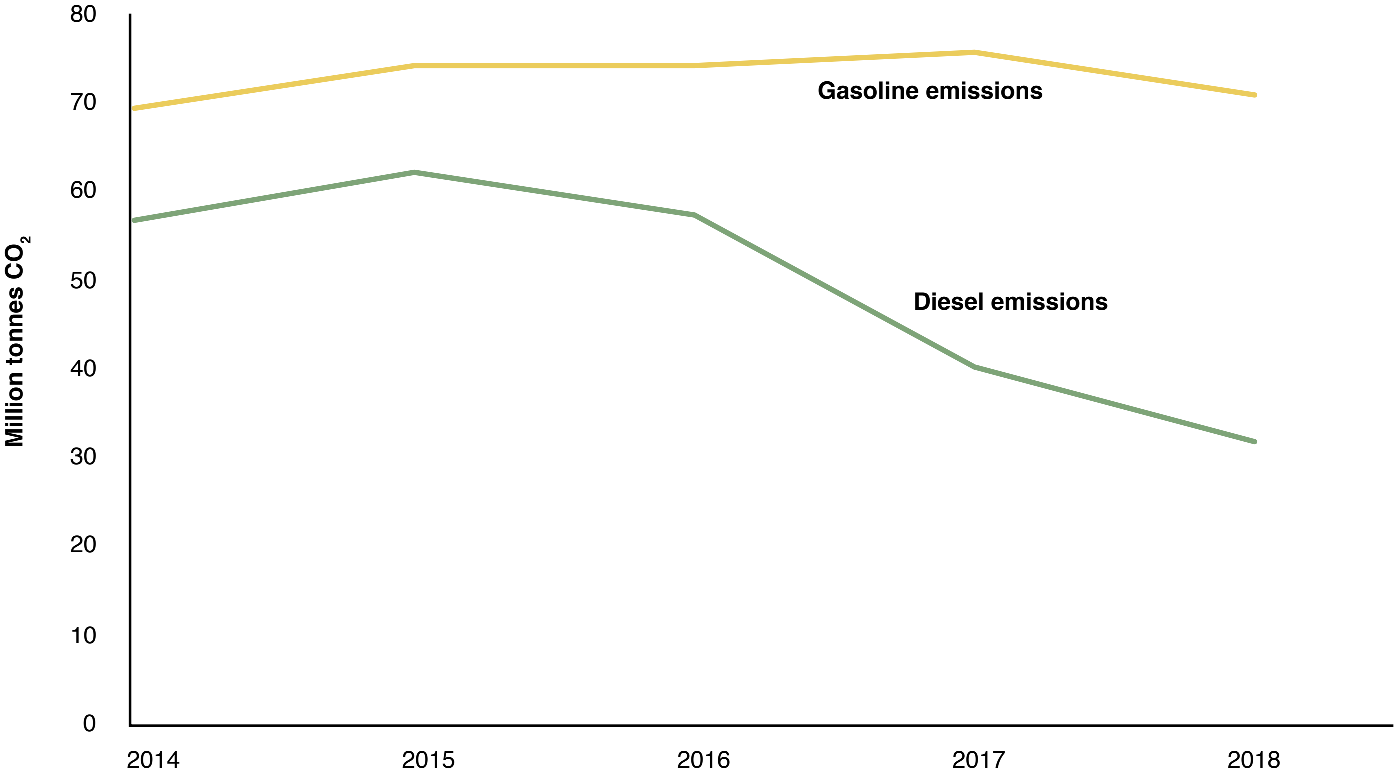
Saudi Arabia's transportation sector accounts for around 21% of the country's total energy consumption, or approximately 1 million barrels of oil equivalent per day (SEECa 2018). Transportation emissions from road, rail and domestic aviation amounted to 105 million tonnes of oil equivalent (Mtoe) in 2018 (IEA 2019). 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 9 $MtCO_2$ or 20%, from 40 $MtCO_2$ in 2017 to 31 $MtCO_2$ in 2018. Gasoline emissions fell by 4 $MtCO_2$, or 6%, from 75 $MtCO_2$ in 2017 to 71 $MtCO_2$ in 2018 (Figure 7).

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). Industrial emissions come from fuel combustion (229 $MtCO_2$) and chemical processes that release CO_2 (27 $MtCO_2$); they have stabilized in recent years after a period of strong growth. The three main industrial sectors, petrochemicals, cement and steel production, account for around 38%, 21% and 11% of total 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.

Figure 7. CO_2 emissions from gasoline and diesel used in transport (2014-2018).



Source: KAPSARC analysis based on Enerdemand (gasoline and diesel fuel consumption).
Note: Data accessed: 9th September 2019; standard emissions factors are used using the EECA (2019) conversion tool.

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. 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).

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.

Table 1. Saudi Arabia's energy price reforms.

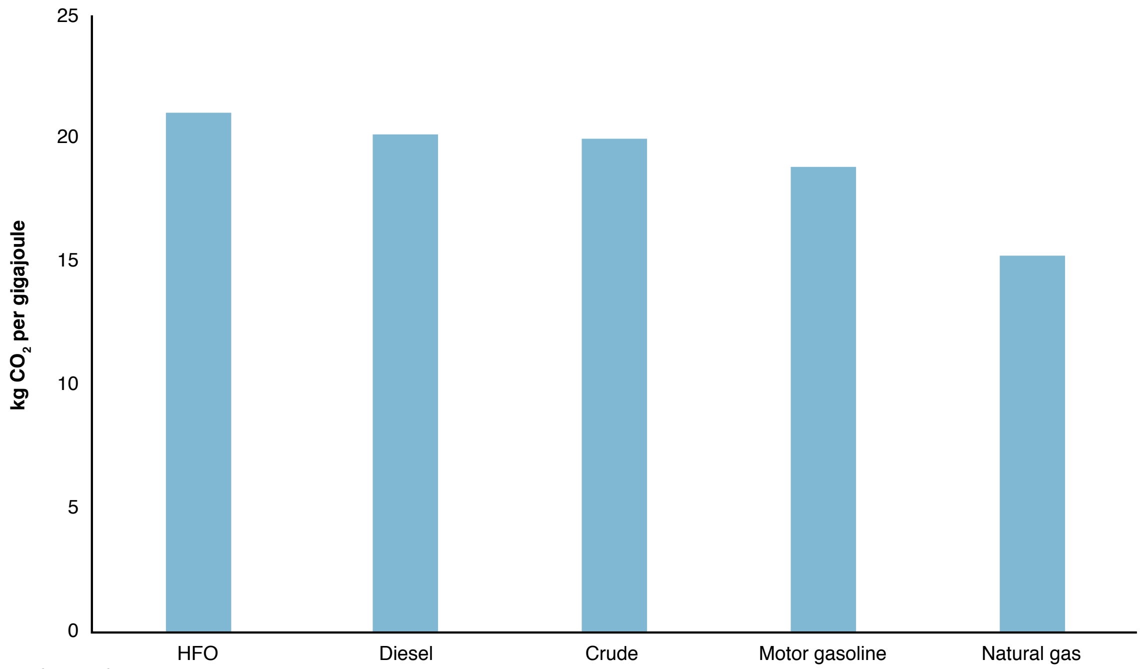
	2015		2016		2018		2015-2018	
Gasoline (95) US$/L	0.16		0.24		0.54		+238%	
Gasoline (91) US$/L	0.12		0.20		0.37		+208%	
Natural gas ($/MMbtu)	0.75		1.25		1.25		+66%	
Ethane ($/MMbtu)	0.75		1.75		1.75		+133%	
Diesel for industry (US$/barrel)	9.11		14.1		16.15		+77%	
Arab light crude (US$/barrel)	4.24		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 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).

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 130 Mtoe, or 62%, in 2018. Meanwhile, the share of natural gas has risen from 71 Mtoe, or 32%, in 2015 to 80 Mtoe, or 38%, in 2018 (Figure 9). From 2010-2018, the production of domestic natural gas grew by an average of 3.6% per year.

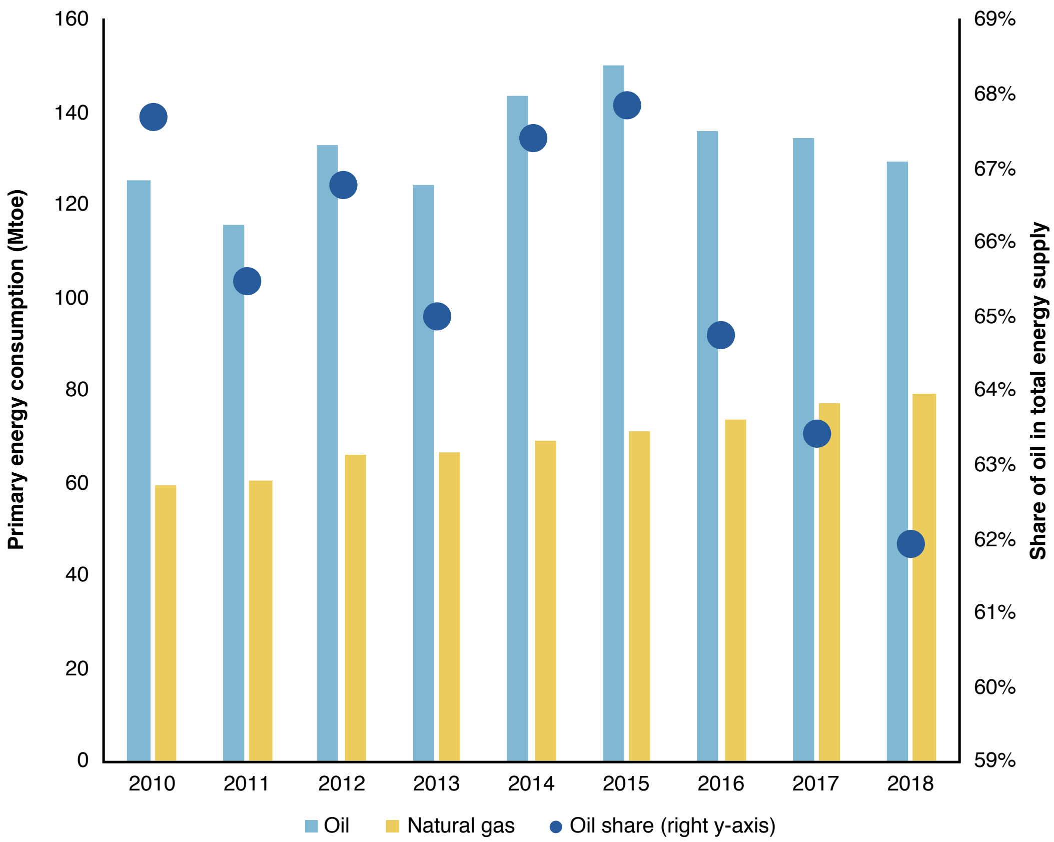
Figure 8. CO_2 content of the main fuels used in Saudi Arabia.



Source: IEA (2017)

Note: HFO = heavy fuel oil

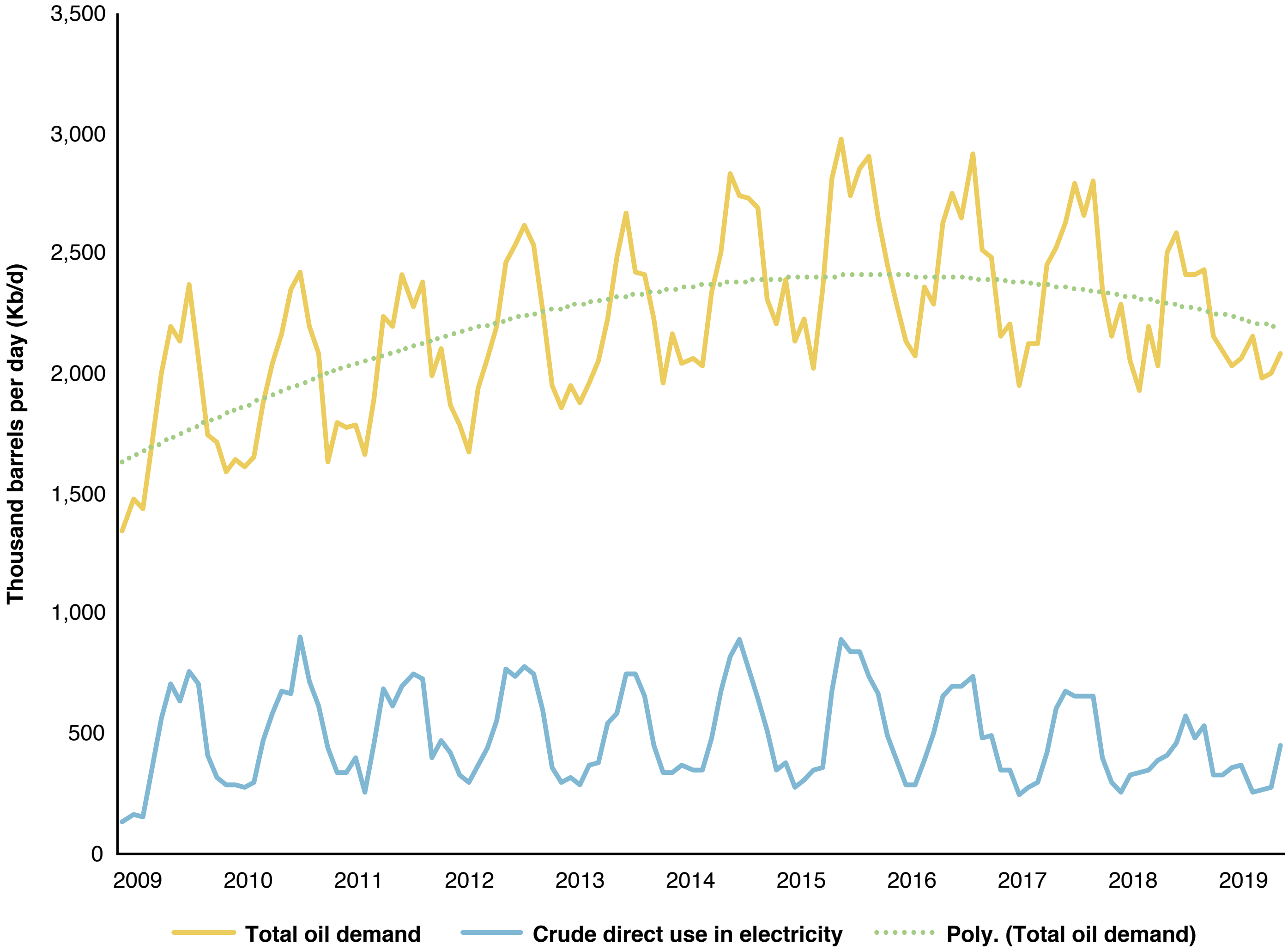
Figure 9. Share of primary energy sources in Saudi Arabia's domestic energy supply.



Source: KAPSARC analysis based on data from Enerdata. Data accessed: 9th Septemper 2019.

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

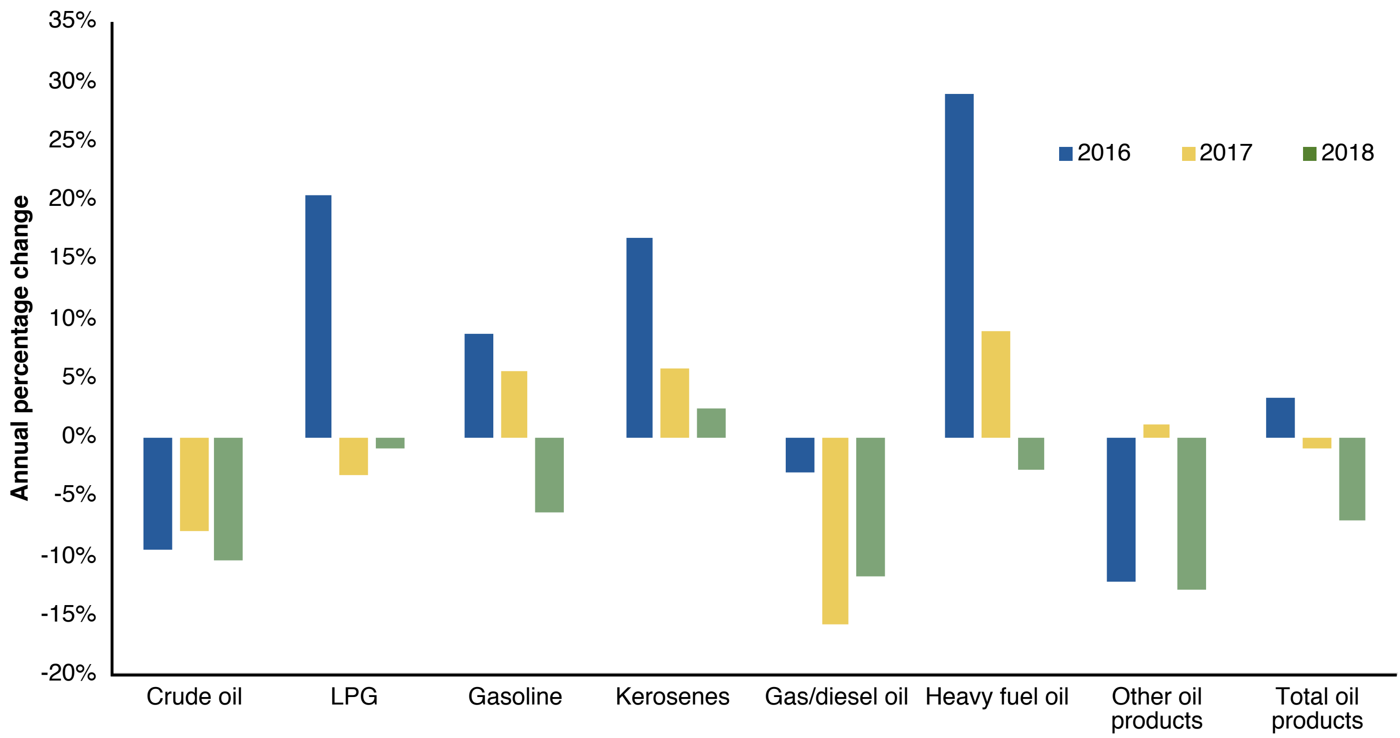


Source: KAPSARC analysis based on JODI data.

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%.

KAPSARC has produced many studies focusing on how Saudi Arabia could reduce the amount of oil it burns through energy efficiency measures and fuel mix changes, among other policy initiatives (Atalla et al. 2017; Krarti et al. 2017; Blazquez et al. 2018). These studies have identified how setting energy intensity or productivity targets are ways in which the government can align economic growth with environmental objectives (KAPSARC-UNESCWA 2017). Recent trends of energy and carbon intensity in the Kingdom suggest that such policies are now beginning to have some success and are contributing to improved sustainability outcomes for the country.

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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