



NDC ASPECTS

Country Report

Transition pathways for Saudi Arabia

August / 2024

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Key messages

- Saudi Arabia has ratified the Paris Agreement, aiming to reduce GHG emissions by 278 MtCO₂e annually by 2030. Saudi officials have announced a net zero target for 2060, without specifying a clear plan, timeline, pathway, and scope for this aspiration.
- Saudi Arabia is currently ranked as the world's largest oil exporter,, with oil exports expected to reach to USD 326 billion in 2022. The fossil fuel sector accounts for approximately 40% of the Saudi Arabia's GDP, highlighting the need for economic diversification.
- Greenhouse gas emissions can be drastically reduced in Saudi Arabia through effective climate policies, such as the electrification of demand sectors, rapid deployment of renewable energy, the use of hydrogen and alternative fuels like biodiesel.

Introduction and Overview

In this document, we provide an overview of the climate policy of Saudi Arabia, and more specifically its Nationally Determined Contributions (NDCs). The Kingdom of Saudi Arabia has a total land area of 2.1 million km² that covers most of the Arabian Peninsula, making it the largest country in the Middle East, as well as the 12th largest worldwide. Saudi Arabia is a monarchy, with the House of Saud being the royal family that rules the country. Furthermore, Saudi Arabia has major financial interests in the fossil fuel industry, being a founding member of the Organization of the Petroleum Exporting Countries (OPEC) and having huge oil and gas resources and reserves. In the rest of the factsheet, we explore the current status of Saudi Arabia, including information for GHG emissions and NDCs, as well as an analysis of climate mitigation scenarios for the future.

Key socio-economic figures and outlook

The economy of Saudi Arabia is largely dependent on oil and gas, with the fossil fuel sector accounting for approximately 40% of the national GDP. The country's oil and gas reserves are among the largest in the world, and Saudi Arabia is currently ranked as the top oil exporter globally, with petroleum exports that amounted to USD 326 billion in 2022 (OPEC, 2023). Saudi Aramco is the national oil company that is primarily state-owned, while also being listed in the stock exchange, with a market capitalization of USD 1.8 trillion. Apart from the fossil fuel industry, the Saudi economy also depends on the finance, retail, construction and infrastructure sectors. In 2016, the Saudi Vision 2030 program was launched by the government, aiming to diversify the national economy, and reduce the dependence on fossil fuels (KSA, 2016). The Saudi GDP was approximately USD2010 600 billions in 2020, and is expected to increase at an average annual rate of 3.5%, reaching 1.6 trillion in 2050 (figure 1). Furthermore, the

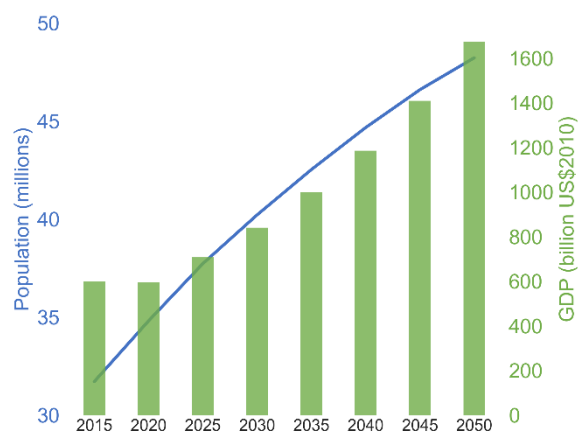


Figure 1: Saudi Arabia's expected population and GDP development.

population of Saudi Arabia was 35 million in 2020, and is projected to reach almost 50 million in 2050 (UN, 2022).

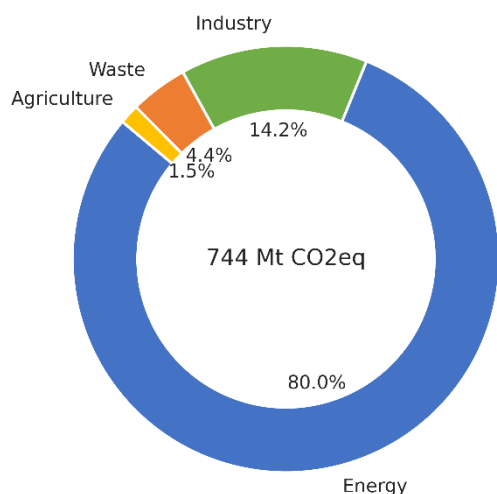


Figure 2: Saudi Arabia’s CO₂eq emissions by sector in 2015. Source: PIK.

The Emission Situation of Saudi Arabia in 2015

As seen in figure 2, the total greenhouse gas (GHG) emissions of Saudi Arabia were 744 MtCO₂eq in 2015, when the Paris Agreement was adopted by most nations of the world. The vast majority of those emissions originated from the energy sector, amounting to 80% of the total, or 592 MtCO₂eq. The industry sector emitted 105 MtCO₂eq of GHGs, accounting for 14.2% of the total. The waste sector followed, with 32 MtCO₂eq, while the agriculture sector emitted 11.1 MtCO₂eq, accounting for only 1.5% of total GHG emissions. Exploring the energy sector in more detail, the largest share of emissions originated from electricity and heat production, amounting to 43%, or 262 MtCO₂eq. Following next was the transportation sector, with 150 MtCO₂eq, which is the equivalent of 25% of total energy sector emissions. The manufacturing and construction sector accounted for a share of approximately 20%.

There was also a considerable amount of fugitive emissions, amounting to 72 MtCO₂eq, or the equivalent share of 12%, while building-related emissions are very small (about 1%). It should also be noted the rate of emissions per capita was close to 23 tCO₂eq, which is one of the highest globally, whereas the emissions intensity of electricity generation amounted to around 604 grams of CO₂eq per kWh (Statista, 2023).

The Current State of GHG Emissions

In recent years, the annual GHG emissions of Saudi Arabia remained relatively stable, with some minor fluctuations. They account for a total amount of 741 MtCO₂eq in 2022, slightly dropping from the total emissions of 2015. The sectoral emissions were slightly modified, with their shares being redistributed. For example, the energy sector share dropped by a few points to 72.7%, or the equivalent of 536 MtCO₂eq. Following next, the industry sector share increased to 20.4%, while the share of the waste sector increased slightly to 5.3%. Finally, the agriculture sector share remained almost unchanged at 1.6%. The emissions intensity of electricity generation slightly decreased to around 570 grams of CO₂eq per kWh, i.e. a reduction of 5.6% from 2015. Those statistics indicate that the country hasn’t implemented any drastic climate measures to reduce domestic emissions, since the Paris Agreement was initially adopted.

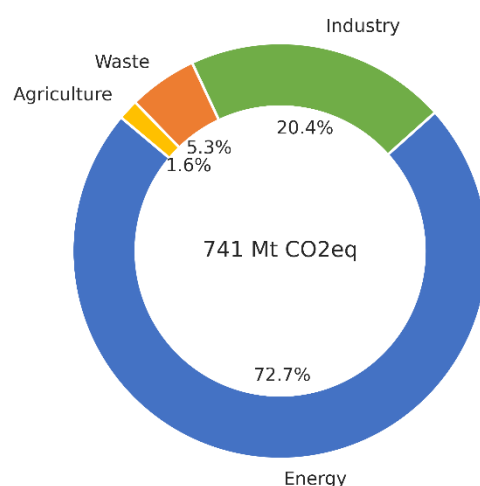


Figure 3: Saudi Arabia’s CO₂eq emissions by sector in 2022. Source: PIK

Nationally Determined Contributions of Saudi Arabia

Saudi Arabia is a signatory to the Paris Agreement and formally ratifying it in November 2016. Nationally determined contributions (NDCs) are commitments made by individual countries with the purpose of reducing their GHG emissions, and contribute to achieving the global targets specified in the Paris Agreement (UNFCCC, 2015). Saudi Arabia submitted their first NDC document in 2016, setting a target of up to 130 MtCO₂eq being avoided annually by 2030, while also aiming for economic diversification and enhanced adaptation to climate change. In October 2021, Saudi officials submitted an updated NDC, including the more ambitious target of 278 MtCO₂eq emissions reduction annually by 2030, with the base year being specified as 2019 (KSA, 2021). We'll focus on the policies described in the updated NDC, as it contains the latest information about the Saudi climate mitigation targets and ambitions. Apart from the NDC target for 2030, Saudi officials have also announced their intention to achieve net zero emissions by 2060. Regardless, no specific details or objectives have been released about the net zero target, hence raising some questions about the country's commitment to ambitious climate policy.

Description	Unconditional Target for 2030	Long-term Target
GHG Mitigation	Reduce emissions by 278 MtCO ₂ e annually by 2030, with 2019 as the base year	Net zero emissions by 2060
Absolute Emissions	800 MtCO ₂ eq	N/A
Compare with 2010	42% above 2010 levels	N/A

Table 1: Basic NDC information of Saudi Arabia

The NDC document elaborates on the specific plans that will be implemented by the Saudi officials, with the intention of achieving their specified emission reduction target for 2030. For example, renewable energy sources will contribute to the diversification of electricity production, accounting for 50% of the electricity mix by 2030. This will be accomplished by a set of reforms, regulations and policies, with the purpose of stimulating private investment in the renewable energy sector. Furthermore, Saudi Arabia also aims to become a global leader in green hydrogen production, with the NEOM plant being expected to produce 650 tons per day. Energy efficiency is another key aspect of the Saudi NDC, laying out a strategy to reduce energy consumption in the sectors of industry, building and land transportation. Also, Carbon Capture, Utilization and Storage (CCUS) is also a technology being emphasized by Saudi officials, as a method of capturing CO₂ emissions and converting them into useful products, or storing them in geological reservoirs.

In addition to climate change mitigation, the aspect of adaptation is also detailed in the Saudi NDC. The country is particularly vulnerable to water scarcity, therefore advanced technologies and methods should be implemented to ensure adequate water supply in the future, which however require extensive use of energy indicating the need to develop efficient energy-water-agriculture nexus methodologies. Those methods include seawater desalination with reverse osmosis, rainwater harvesting, new irrigation techniques, and the increased usage of treated wastewater. The NDC document further expands on the strategy to ensure appropriate climate change adaptation in Saudi Arabia, such as reducing coastal erosion, desertification management, afforestation, biodiversity protection and others. Regardless, Saudi Arabia has been strongly criticized by experts and climate stakeholders for its plans to increase oil output, while relying heavily on CCUS, and making little progress to reduce emissions since the Paris Agreement adoption (CAT, 2023).

Key Decarbonization Pathways

In this section, we explore the decarbonization pathways of Saudi Arabia, based on the targets laid out in the NDC and its Long-term target, as well as expert analysis and model-based scenarios. We evaluate the climate pledges of Saudi Arabia, and assess their alignment with the Paris Agreement goals, i.e. the 1.5°C and 2°C global temperature increase limits. Notably, a business as usual (BAU) projection was omitted from the Saudi NDC, making it difficult to compare the developed scenarios quantitatively. Furthermore, the net zero target has merely been announced by Saudi officials, without providing any specific details on the scope, timeline, and intended pathway to achieve it. Therefore, the scenarios used in the following analysis are based on expert assessment of the Saudi climate policy ambitions, along with information from the updated NDC document. In particular, we develop two scenarios: a Baseline (BAU) assuming the continuation of current trends and implementation of already legislated policies, without further strengthening; and the NDC/LTT scenario that assumes the implementation of the NDC targets for 2030 and the Long-term net zero target based on the imposition of ambitious climate policies aiming to reduce emissions. To quantify the impacts of these scenarios, we use the MENA-EDS model (Fragkos et al, 2013), an energy systems model covering both energy demand and supply that has been utilized in various climate policy studies and academic research, focusing on Middle East and North Africa countries (Fragkos, 2023).



Impact of Saudi NDCs on Primary Energy Consumption

We begin the analysis by focusing on primary energy consumption, for the BAU and NDC/LTT scenarios. Figure 4 shows that the primary energy consumption is projected to steadily increase in the projection period, reaching approximately 19 EJ/year in 2050, driven by economic growth, rising living standards, as well as the growing population of Saudi Arabia. This NDC/LTT scenario projects that energy consumption will increase at a much lower rate until 2040 compared to Baseline, before reaching a plateau in the decade 2040-2050. This major difference between the two scenarios arises from the improved energy efficiency on all sectors included in the Saudi NDC. In the BAU scenario, primary energy is dominated by fossil fuels, with oil and gas having a share of 45% and 48% respectively in 2050 (93% share of fossil fuels in 2050). Renewable energy sources are underutilized, amounting only to 7% of the primary fuel mix, reflecting the lack of ambitious climate policies in the BAU scenario and the continuation of a fossil-driven economic paradigm. The NDC/LTT scenario paints a completely different picture, with the share of fossil fuels dropping to only 51% in 2050, accompanied by a large increase in the share of renewable energy in order to achieve the net-zero goal. In particular, the share of solar, wind and biomass (mostly imported in the form of biofuels from large bioenergy exporters) in primary energy increases to 21%, 17% and 11% respectively in 2050. Solar and wind energy are mostly used to decarbonize electricity production, while biomass is mostly used in demand sectors and specifically to decarbonize land, air and water transport through the use of biofuels. The significant uptake of renewable energy sources is one of the main plans of the Saudi NDC, and is therefore being reflected in the modelling results. However, the implementation of renewable energy projects in the country has been quite slow indicating the need to accelerate efforts to transform its energy sector towards a low-emission paradigm by overcoming political, economic, technical and societal barriers.

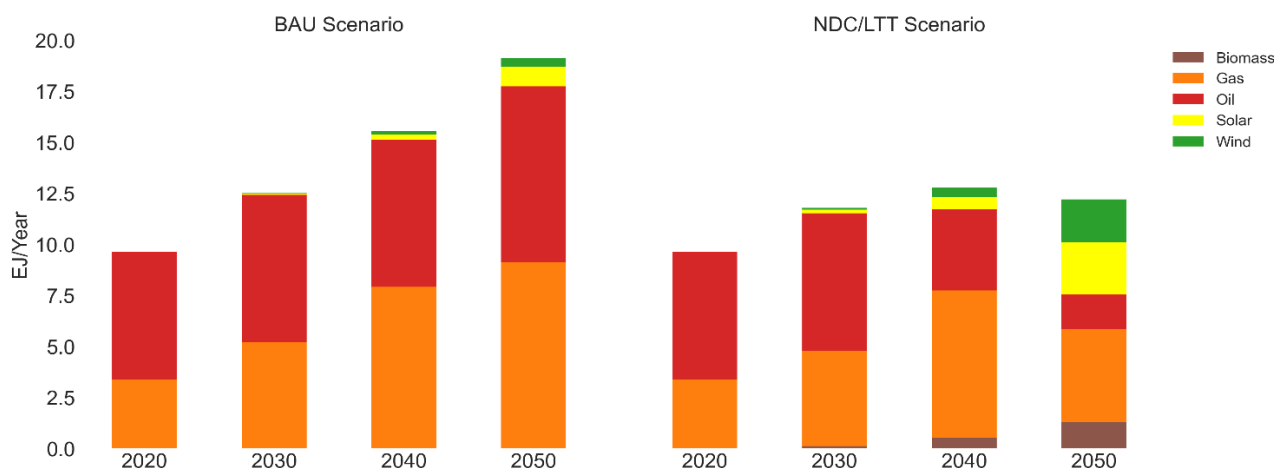


Figure 4: Primary energy consumption of Saudi Arabia in the BAU and NDC/LTT scenarios. Source: MENA-EDS Model

Sectoral System Transformations

In this section, we explore the sectoral transformations imposed in the NDC/LTT scenario, created with the MENA-EDS model. Our analysis covers all the main energy demand and supply sectors, including industry, buildings, transportation, and electricity production. As seen in figure 5, final energy consumption keeps increasing in both scenarios driven by increasing population, economic activity and rising standards of living, although at a lower rate in the NDC/LTT scenario compared to the BAU. This result is driven by improved energy efficiency standards, as well as the adoption of advanced technologies that are less carbon and energy intensive, including electric vehicles and electricity use in manufacturing processes.

Industry

The Saudi industrial sector remains heavily reliant on fossil fuels in the BAU scenario, with oil and gas accounting for 80% of the fuel mix in 2050. The share of electricity steadily increases, but accounts for only 20% in 2050 while sectoral energy consumption keeps increasing rapidly indicating a major deficit in current climate policies and the large challenges to transform the industry sector in the country. In contrast, the NDC/LTT scenario projects that fossil fuel share will drop sharply to 43% in 2050, whereas electricity usage will significantly increase, to a total share of 41% with the electrification of low and medium-temperature heat being a prominent strategy already in the medium term (2030/2035). Furthermore, hydrogen will also play an important role, with a share of 16% in the industrial fuel mix in 2050, especially in the form of green hydrogen (produced via electrolysis of renewable-based electricity) used in specific industrial uses like chemicals, refineries, and steelmaking. As mentioned previously, Saudi officials have highlighted their intentions to become global leaders in hydrogen production given the large, low-cost solar resources of the country.

Buildings

The Saudi buildings sector is almost exclusively powered by electricity, amounting to a share of 96% in the BAU scenario in 2050, illustrating the significant progress already achieved to reduce direct fossil fuel use in the sector. Fossil liquids have a small share, accounting for only 4% of the fuel mix, reflecting the relatively minor heating requirements for residential and commercial buildings in the country given its warm climate. In the NDC/LTT scenario, electricity will cover practically the entire energy needs of the buildings sector, including the constantly increasing cooling requirements as the global mean temperature is projected to keep increasing.

Transportation

In the BAU scenario, transportation is predominantly reliant on fossil liquids, having a share of 97% in 2050 with electricity making only small inroads in the transport fuel mix (3% in 2050) indicating the extensive challenges to decarbonize the transport sector and the strong requirement for more ambitious policies to transform the sector towards a low-emission and sustainable paradigm. The NDC/LTT scenario is radically different, with a massive expansion of low-carbon technologies and fuels, as electricity share is projected to massively increase to 45% in 2050 illustrating an ambitious, yet feasible, transformation pathway for the sector based on the enhanced cost-efficiency of EVs compared to conventional fossil ICEs, driven by technological maturity, low electricity prices (due to the vast solar potential) and the removal of inefficient fossil fuel subsidies. The usage of fossil liquids is expected to drop drastically, as conventional internal combustion engine (ICE) vehicles are increasingly being replaced by electric vehicles (EV). Imported (Bio)fuels are also expected to play an important role, with a share of 30% in 2050,



through the increased usage of alternative fuels, such as ethanol, biodiesel and others both in road transport and in aviation. This scenario highlights the gradual phase down of ICE vehicles and the adoption of EVs, that are more sustainable and environmentally friendly.

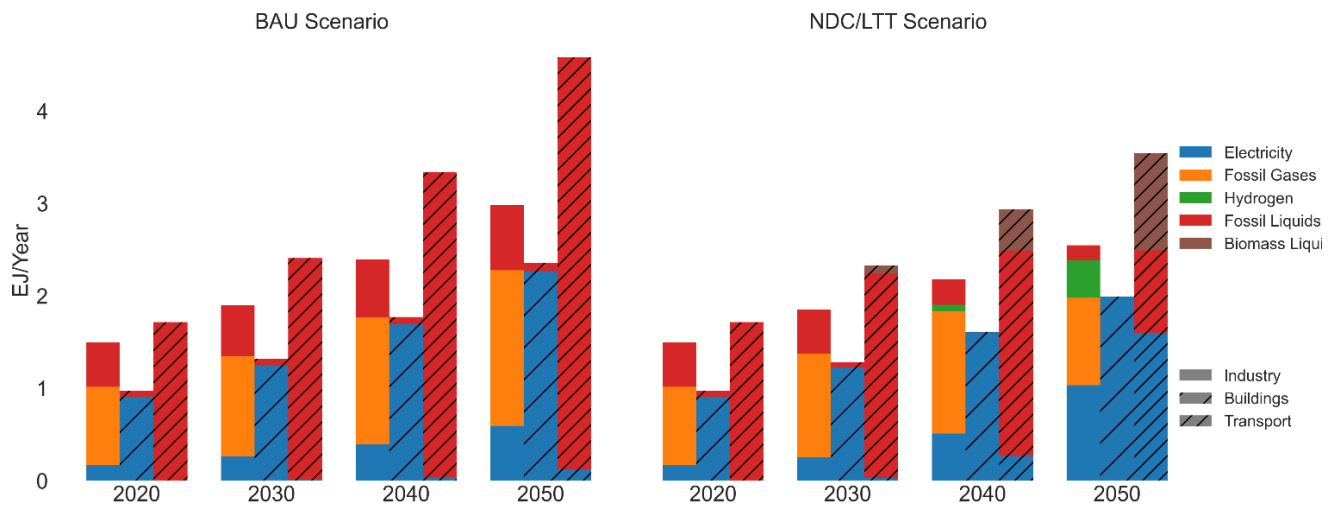


Figure 5: Final energy consumption of Saudi Arabia by main sector and fuel in the BAU and NDC/LTT scenarios. Source: MENA-EDS Model

Electricity Production

Regarding electricity production, there are striking differences between the BAU and NDC/LTT scenarios. First, total electricity production is expected to be 55% higher in the NDC/LTT scenario compared to BAU, because of the strong electrification of the industry and transportation sectors, resulting in higher demand for electricity. In the BAU scenario, the electricity sector is largely dependent on fossil fuels, with gas and oil accounting for 65% of the power generation mix in 2050. Renewable energy sources are also utilized, with solar and wind energy getting a share of 24% and 11% respectively driven by their declining costs and Saudi Arabia’s willingness to diversify its energy mix. The NDC/LTT scenario projects a higher uptake of renewable energy, accounting for a total share of 80% of electricity produced in 2050, hence requiring huge investments in solar PV and wind installations, accompanied by storage to ensure system flexibility and balancing of variable renewable energy generation. Fossil fuel usage is expected to drop sharply, accounting for 20% of the power mix, while partially utilizing CCS technologies to further reduce emissions, as highlighted in the Saudi NDC document.

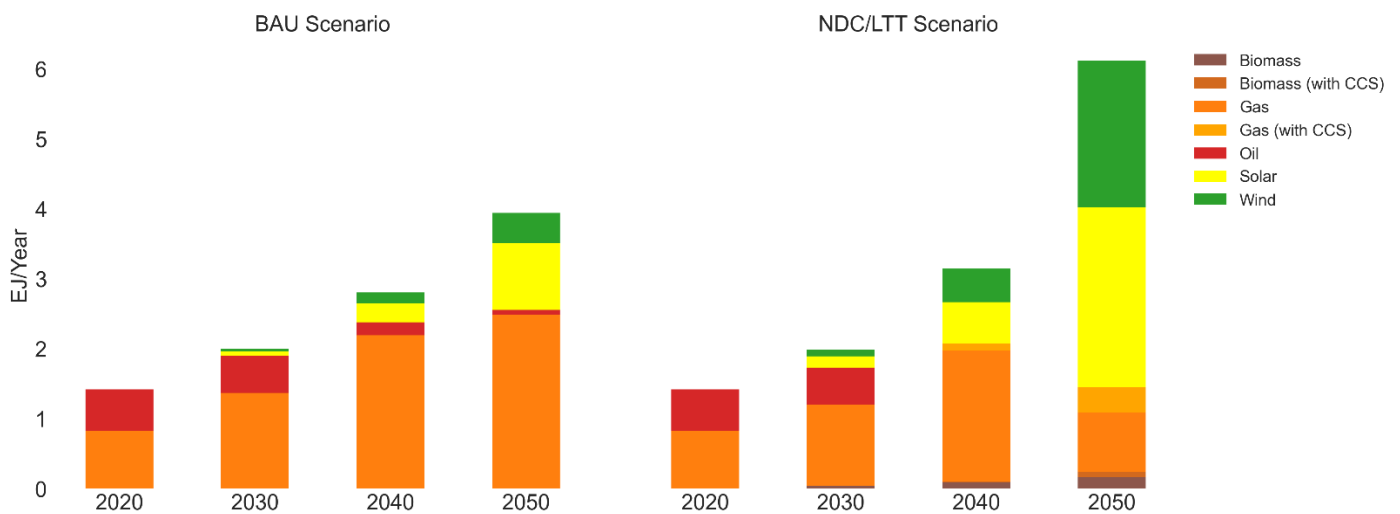


Figure 6: Electricity production of Saudi Arabia by fuel in the BAU and NDC/LTT scenarios. Source: MENA-EDS Model

Greenhouse Gas Emissions

In this section, we analyze the CO₂ emission trajectories of the Saudi energy sector, in the BAU and NDC/LTT scenarios. Emissions have a strong upward trend in the BAU scenario, due to the economic growth and lack of ambitious climate policies, increasing from 516 MtCO₂ in 2020, to 680 Mt in 2030, and further to about 1000 Mt in 2050. In contrast, CO₂ emissions follow a significantly different trajectory in the NDC/LTT scenario; in the current decade, CO₂ emissions increase but at a slower pace compared to BAU from 516 Mt in 2020 to 620 Mt in 2030, followed by their stabilization in the next decade, and a sharp reduction after 2040, with CO₂ emissions projected to drop to only 268 Mt in 2050 (i.e. a 50% reduction over 2020-2050). Still, Independent experts have assessed that Saudi climate pledges are not aligned with the Paris Agreement goal of limiting global mean temperature increase to 1.5°C by the end of the century, and characterized them as “critically insufficient”. Based on the same assessment, annual GHG emissions of Saudi Arabia should drop significantly faster to a level of 500 MtCO₂eq by 2030, in order to accomplish the 1.5°C temperature increase goal (CAT, 2023).

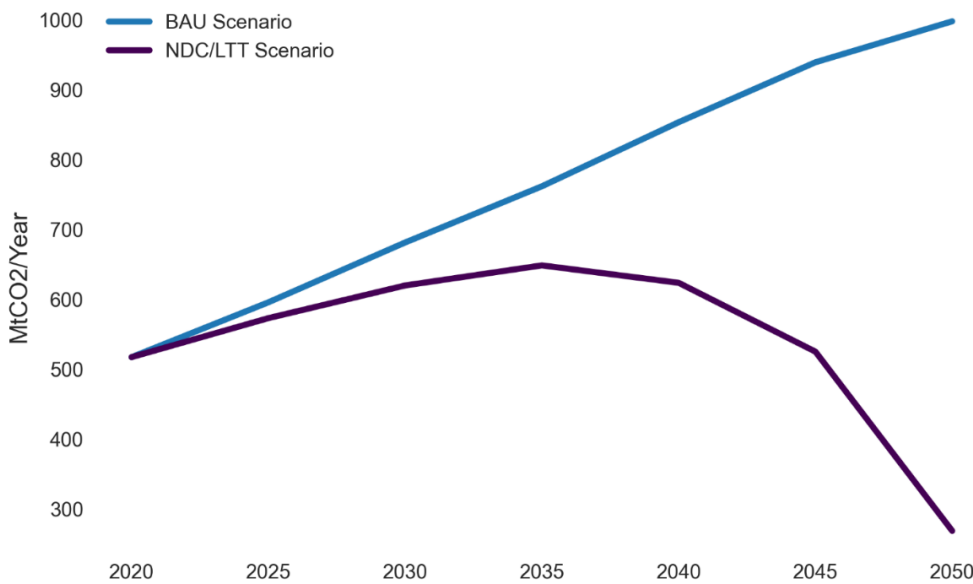


Figure 7: Annual CO₂ emissions of the Saudi energy sector in the BAU and NDC/LTT scenarios. Source: MENA-EDS Model

Key messages for next NDCs

Our analysis indicates the NDC/LTT targets of Saudi Arabia are achievable, driven by effective decarbonization measures and climate policies, such as the electrification of demand sectors, and rapid deployment of renewables, leading to the drastic reduction of GHG emissions. Achieving this goal will be challenging for a number of reasons. As the top exporter of oil worldwide, Saudi Arabia has enormous financial interests in fossil fuels, therefore creating a strong economic incentive against decarbonization. The hugely successful Saudi Aramco is one of the largest companies in the world, with its revenue reaching approximately USD 600 billion in 2023, creating thousands of well-paid jobs for Saudi Arabia’s citizens. Furthermore, transforming the economy will be disruptive and may lead to social unrest and discontent, which is a challenging situation for officials.

Saudi Arabia is particularly vulnerable to the effects of climate change due to its geographical location, with research showing that droughts have become more frequent in recent years (Al-Wabel, 2020). Several other studies indicate that average temperature of Saudi Arabia has increased significantly, resulting in serious thermal discomfort during summer months, hence threatening future human survival in the region (Odnoletkova, 2021). In June 2024, extreme heat killed hundreds of people during the pilgrimage to Mecca, highlighting the fact that climate change can have tragic consequences (Guardian, 2024). Along with extreme weather events, Saudi Arabia is vulnerable because of water scarcity, desertification and biodiversity loss. Saudi officials must therefore raise their climate policy ambitions, by presenting an ambitious and comprehensive net zero plan with clear scope, timeline and aspirations to ensure alignment with the Paris temperature goals. As part of its next NDC, the country also focus on diversifying its economy and phasing out fossil fuels, while also committing to ending new investments in

oil and gas production, and significantly increasing the pace of renewable energy deployment. Saudi officials should also focus on strengthening their NDC target for 2030, and clarify the assumptions behind the 2060 net zero target, which currently lacks transparency and credibility, without providing a clear emissions reduction pathway. This will ensure a prosperous future for the Saudi people, and the rest of humanity, in line with the Paris Agreement goal of limiting temperature rise to 1.5°C.

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NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

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