CHAPTER 18

# United States Country Report

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# 1. Introduction

The United States (US) is the fourth largest country in the world by total area and the third largest by population. Since 2010, the country's population has grown by an average of about 2.3 million people per year, reaching approximately 332.4 million people in 2021 (US Census Bureau, 2022a & 2022b) with over 80% living in urban areas (US Census Bureau, 2010 & World Bank, 2022a).

The US is the world's first or second largest economy (depending on the metric), with a gross domestic product (GDP) of $23 trillion and per capita income of $70,480 as of 2021 (World Bank, 2022b & World Bank, 2022c). By sector of origin, roughly 80% of the US GDP can be linked to services, while around 18% is linked to industry including construction (World Bank, 2022d, and World Bank, 2022e).Agriculture, forestry, and fishing collectively make up just 1% (World Bank, 2022f).More broadly, international trade also plays a crucial role in the overall strength and health of its economy, with data from the World Bank suggesting that roughly one quarter of the US GDP is linked to trade (World Bank, 2022g).

## 1.1. Energy Situation

The United States is the world's second largest consumer of energy (first, on a per capita basis) but its consumption growth rate has slowed significantly in recent years. In 1990, its final energy consumption was 1,293.54 million tonnes of oil equivalent (Mtoe). Over the following decade, consumption increased by nearly 20% (reaching 1,546.28 Mtoe in 2000), and then grew by less than 3% over the next two decades (reaching 1,588.48 Mtoe in 2019).

In terms of how the US might meet its demand for energy, the country has long had abundant and diverse resources. This includes ample reserves of fossil fuels, such as coal, oil, and natural gas, as well as significant potential for geothermal, wind, and solar energy. Until recently, much of this energy potential was deemed impractical or uneconomical, with coal dominating domestic energy production until the early 2000s. However, advancements in technology, declining production costs, and favorable conditions for development and investment have sparked a surge of interest in the domestic production of oil, natural gas, and renewable energy sources like wind and solar energy. Consequently, the country's natural gas and crude oil have both doubled since 2005 (US Energy Information Administration, 2022a). Meanwhile, in the past 10 years alone, wind power capacity in the US has more than doubled, while solar power capacity has increased twenty-fold (US Energy Information Administration, 2022b).

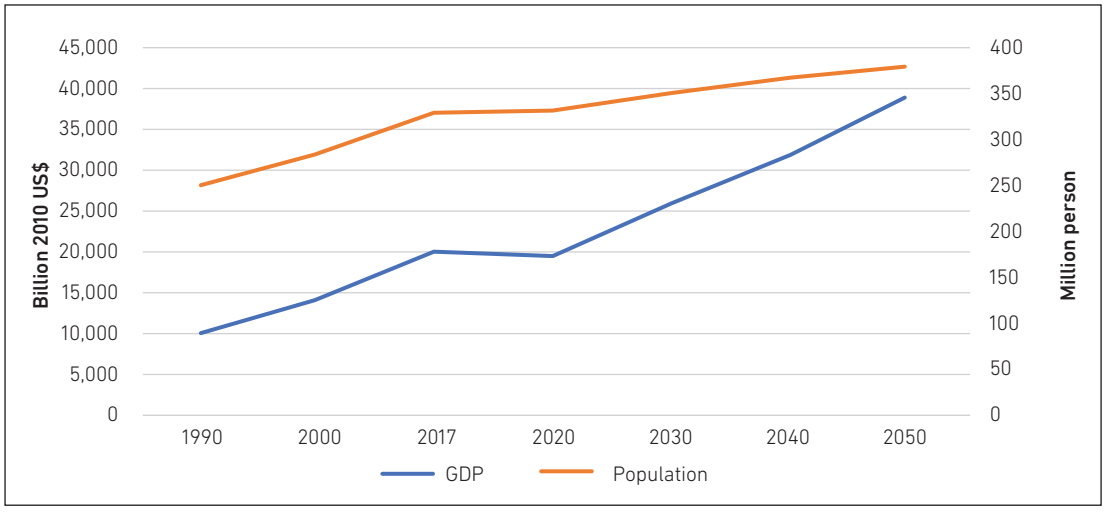
These developments have had at least two ripple effects on US energy outlooks. First, they have accelerated the ongoing shift towards cleaner consumption patterns, as there is now a wider range of available lower- and zero-carbon supply options. In 2014, natural gas surpassed coal as the single largest share of US power generation and, since then, has further increased its share. Consumption of wind and solar has also continued to hit new record highs (US Energy Information Administration, 2022c & 2022d, and Clara. G, 2022). Collectively, these shifts have also had an additional effect of offsetting expected growth in US carbon dioxide emissions. Despite the rise in total final energy consumption since 1990, US $CO_2$ emissions in 2019 were only 0.3 million tonne of carbon (Mt-C)2 higher than levels in 1990 (i.e., 4,743.6 Mt-C vs. 4,743.3 Mt-C).

The second major impact of these shifts is in reshaping the country's expected outlook for trade in energy. Increased oil and natural gas production has not only reduced the need for imports from Canada and other countries but also bolstered the country's potential to serve as an important global energy supplier. As of 2021, the US has already exported substantial volumes of liquefied natural gas (LNG) to Japan, Taiwan, India, South Korea (henceforth, Korea), and China (US Energy Information Administration, 2022e). Reduced domestic coal demand led to increased focus on exporting coal, with India, Japan, and South Korea amongst the top export markets for US coal (US Energy Information Administration, 2022f). While these trends offer potential for US energy production to enhance regional energy security and trade balances, several factors may limit interest in otherwise available US supplies and technologies. This includes potential bottlenecks in energy export and import infrastructure, as well as intense competition between the US and other economies for global market share amidst growing climate change concerns.

# 2. Modelling Assumptions

Over this study's outlook period of 2019–2050, GDP and population counts are projected to grow, though at markedly different rates, resulting in a trend of an overall rising per capita GDP (Figure 18.1). While US birth rates are projected to remain below replacement levels during the outlook window, the population continues to grow overall due to expectations for sustained immigration and improved life expectancies. However, at 0.5% per year, the population growth rate for the outlook period is still at a notably slower pace than the 0.9% per year of the 1990–2019 period.

**Figure 18.1 Gross Domestic Product and Population, 1990–2050**




GDP = gross domestic product.

Source: Authors' calculation, 2022.

Between 1990 and 2019, the GDP grew at an average annual rate of 2.5%. Despite significant disruption during the 2007–2008 global economic crisis and the 2020–2021 coronavirus (COVID-19) crisis, the US economy has managed to maintain steady growth, albeit at a relatively modest pace. As of this writing, it also appears to have recovered at a national-level from the downturns brought on by the disruptions in regular travel and business patterns during the COVID-19 pandemic. Hence, despite ongoing uncertainty around near-term economic outlooks, this model projects that US GDP growth rates will re-stabilise over the outlook period at an annual average growth rate of 2.2%. This estimate aligns with anticipated progress in efficiency, productivity, and modest yet steady population growth. It also assumes that the US will maintain its leadership in innovation in emerging fields alongside continued global market recovery.

With these conditions in mind, this study estimates the energy saving and $CO_2$ emission reduction potential by comparing the results of a Business-as-Usual (BAU) Scenario with the cumulative impact of several Alternative Policy Scenarios (APS). In the BAU scenario, longstanding market trends are expected to persist. This includes a decline in coal and nuclear energy due to unfavourable economic and social license in the US compared to non-hydro renewables and natural gas. Coal, in particular, is expected to decline significantly due to the competitiveness of alternative generation options and the retirement of a number of older, less efficient coal-fired plants. Despite increasing use of alternative fuel and the adoption electric vehicles, the US transport is anticipated to continue relying heavily on oil. This is partly due to limited means and incentives for large-scale switching compared with the tools available within the power sector.

The APS, in contrast, assumes the full implementation and realisation of ongoing policy efforts, including improved energy efficiency of final energy demand; thermal power generation; nuclear energy as a source of baseload power generation; and higher contribution from renewable energy in total supply. The analysis is based on national and state laws and policies in place as of 2021. Importantly, this cut-off date means that the potential impacts of the United States' Inflation Reduction Act, which was signed into law in August 2022, are not covered by APS scenario findings.

Finally, and new to this year's report, is the inclusion of a 'carbon neutral', or low carbon energy transition (LCET) scenario, which models what shifts, if any, might enable a country to reach net-zero $CO_2$ emissions on an annual basis by 2050. In the United States, these shifts involve implementing new incentives, tools, and approaches that prioritize decarbonization more aggressively than those in APS. However, these measures are still technically feasible and potentially socially acceptable. For example, this could mean setting more ambitious deadlines for phasing out combustion engines without suggesting the elimination of all motorized vehicles. The United States' *Pathways to Net-Zero Greenhouse Gas Emissions by 2050* and executive orders by the Biden administration on decarbonisation provide the foundation for scenario modelling in this context. These efforts focus on reducing greenhouse gas emissions in power, transport, and industry. However, in some cases, divergences in the findings of these official reviews and this report do occur. Such differences can arise from variations in methodologies, such as assumptions about economic conditions and technological advancements between 2019 and 2050.

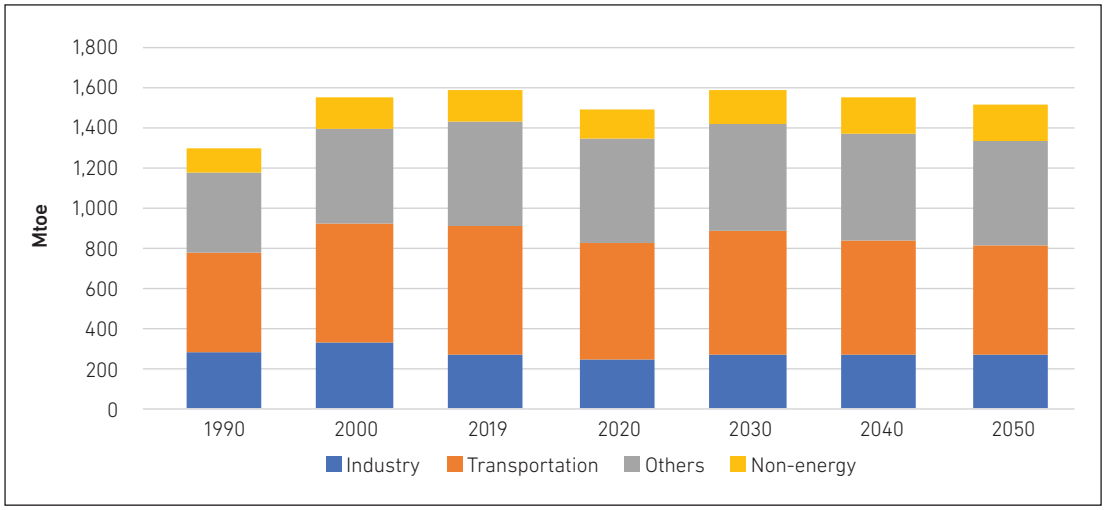
# 3. Outlook Results

## 3.1. Business-as-Usual Scenario

### 3.1.1. Final Energy Consumption

Under the BAU scenario, total final energy consumption is anticipated to decline slightly between 2019 and 2050 at an average annual rate of decrease of 0.2% (Figure 18.2). Transport is a key driver of this decline, as otherwise expected, growth linked to a modest rise in vehicle ownership and utilisation is more than offset by increased switching to cleaner, more efficient vehicles as well as other structural changes within the sector. However, an otherwise steeper decline in overall US energy consumption is offset by consumption increases in other sectors. Non-energy sector consumption, for example, is expected to see an average annual growth of 0.5%. Meanwhile, both industry and others are expected to see relatively flat growth during the outlook period.

**Figure 18.2 Final Energy Consumption by Sector, Business-As-Usual**
(Mtoe)



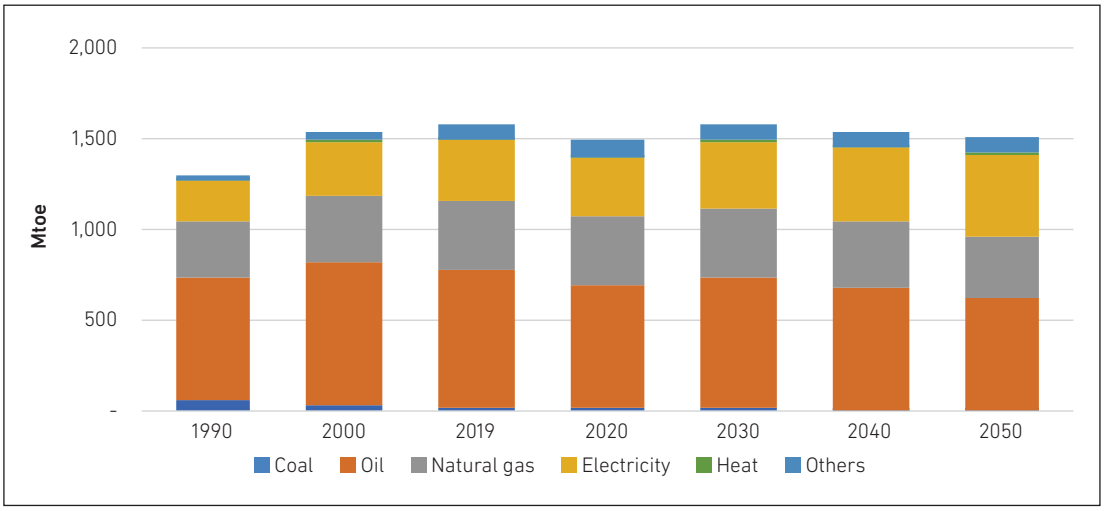

Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

In this context, oil consumption declines and, by 2050, is anticipated to fall to 616.91 Mtoe (roughly 10% below levels in 1990). Coal consumption also consistently declines throughout the entire 2019–2050 period. In contrast, electricity consumption grows from 329.32 Mtoe in 2019 to 448.68 Mtoe in 2050 (Figure 18.3). which (amongst other things) reflects headwinds in newly This growth is influence by factors such as the electrification of various sectors of the US economy, including transport and industry. Natural gas consumption also increases overall but may reach its peak and subsequently decline after the 2030s. This is due to increased competition from other energy sources in various end-use sectors.

**Figure 18.3 Final Energy Consumption by Fuel Under Business-As-Usual**
(Mtoe)




Mtoe = million tonnes of oil equivalent.

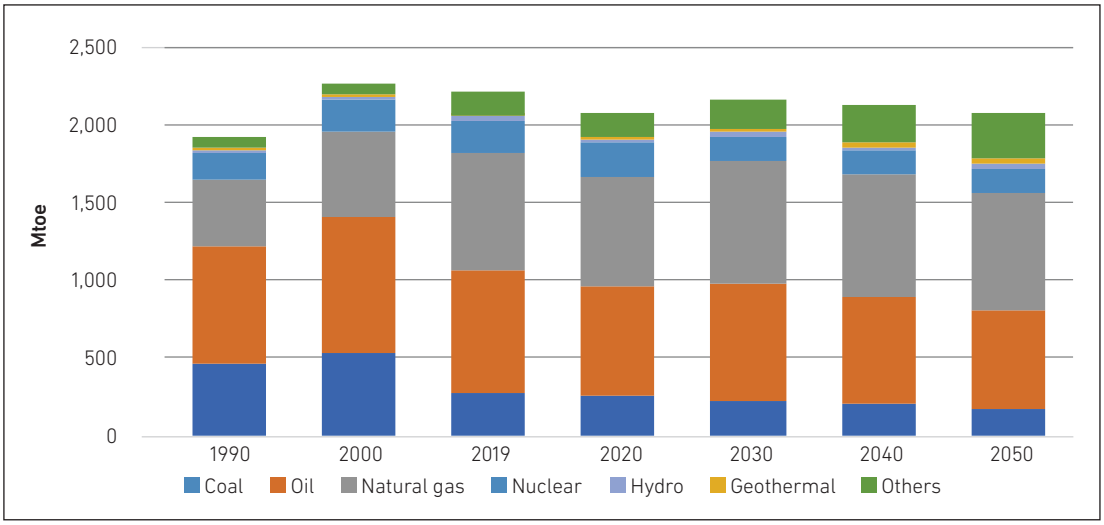
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

## 3.1.2. Primary Energy Supply

Under BAU, total primary energy supply is anticipated to decline from 2,212.75 Mtoe in 2019 to 2,082.97 Mtoe in 2050, with an average annual rate of decrease of 0.2%. Coal consumption is anticipated to decline at a rate of 1.6% during this period, while nuclear declines by 1.1%. In contrast, non-hydropower renewables experience the largest growth in consumption at 4.8%, followed by geothermal at 4.6% (Figure 18.4).

**Figure 18.4** Primary Energy Supply Under Business-As-Usual




Mtoe = million tonnes of oil equivalent.

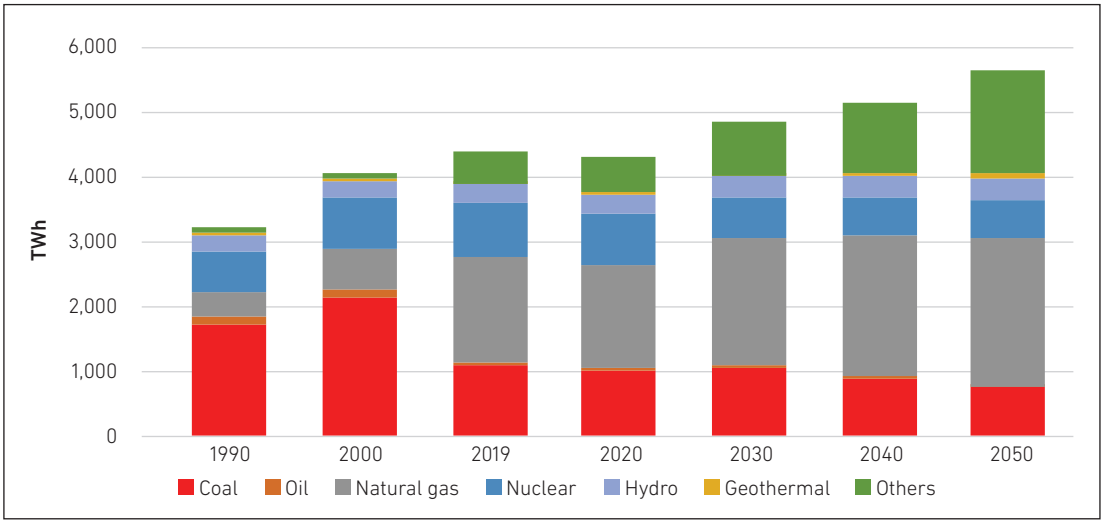
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

### 3.1.3. Power Generation

Under the BAU scenario, electricity generation in the United States, increases over the outlook period, though at a modestly slower pace than the previous 25 years. Generation output increases from 4,370.99 terawatt hour (TWh) to 5,634.40 TWh between 2019 and 2050, for an average annual growth rate of 0.8% (Figure 18.5). The retirement of older, less efficient coal-fired plants, technological advancements promoting more efficient consumption, and broader market and policy forces that drive input switching all contribute to shaping this outlook. In line with this, coal declines steadily at 1.3% a year and accounts for only 12.7% of all US power generation by 2050 (down from 24.5% in 2019). Meanwhile, natural gas gains in relative competitiveness and, by 2050, represents 41.1% of the overall mix. Even so, the largest average annual growth rates are seen in non-hydro renewables, most prominently solar and wind. When combined with shares for nuclear and hydro, these growth rates suggest that by 2050, roughly 46% of power generation output may come from zero-carbon energy sources.

**Figure 18.5** Power Generation Under Business-As-Usual
(TWh)




TWh = terawatt hour.

Note: 'Others' includes residential and commercial sectors.

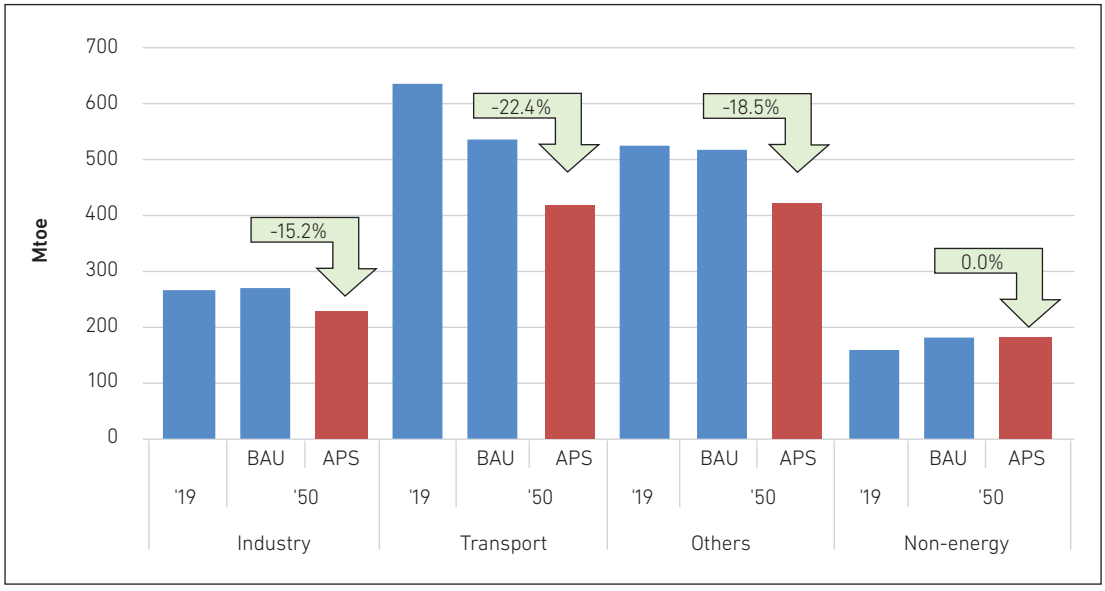
Source: Authors' calculation.

## 3.2. Alternative Policy Scenarios

### 3.2.1. Final Energy Consumption

Under the APS, this study projects that an even more dramatic decline in total final energy consumption will occur in the US. To that end, under the APS, such consumption declines from 1,588.48 Mtoe to 1,251.43 Mtoe during 2019–2050. When compared with the BAU, this shows an energy savings of roughly 258 Mtoe or 17.1% during the outlook period. Transportation saves 120 Mtoe (22.4%); industry, 41 Mtoe (15.2%); and residential and commercial (others), 96 Mtoe (18.5%) (Figure 18.6). Meanwhile, contrary to expectations under BAU, both industry and residential and commercial sectors experience a decline in overall consumption.

**Figure 18.6 Final Energy Consumption by Sector, Business-As-Usual vs. Alternative Policy Scenario**
(Mtoe)




APS = alternative policy scenario, BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes residential and commercial sectors.

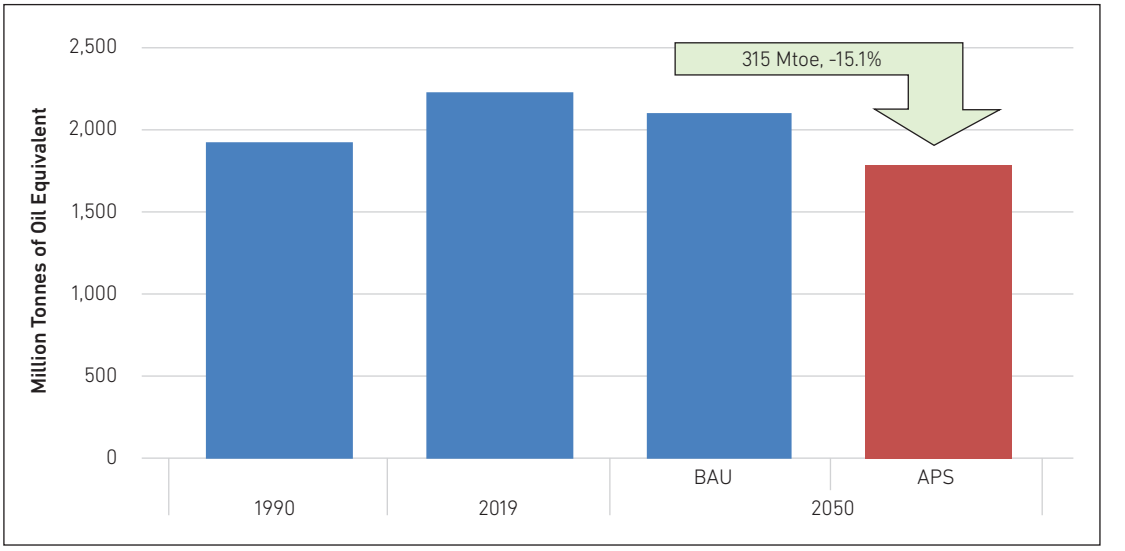
Source: Authors' calculation.

These declines are not evenly distributed across fuel type. While coal, oil, and natural gas all realise even faster rates of decline over the outlook period under the APS, the difference between the APS and BAU is sharpest for natural gas. Meanwhile, electricity consumption grows – and, indeed, is modestly higher than in BAU – given factors such as an increased uptake in electric vehicles.

### 3.2.2. Primary Energy Supply

Under APS, the United States' primary energy supply is anticipated to decrease from 2,212.75 Mtoe in 2019 to 1,767.98 Mtoe in 2050 (Figure 18.7). This implies that in 2050, primary energy supply under APS will be around 315 Mtoe or 15.1% lower than BAU.

**Figure 18.7 Primary Energy Supply in Business-As-Usual vs. Alternative Policy Scenario**
(Mtoe)

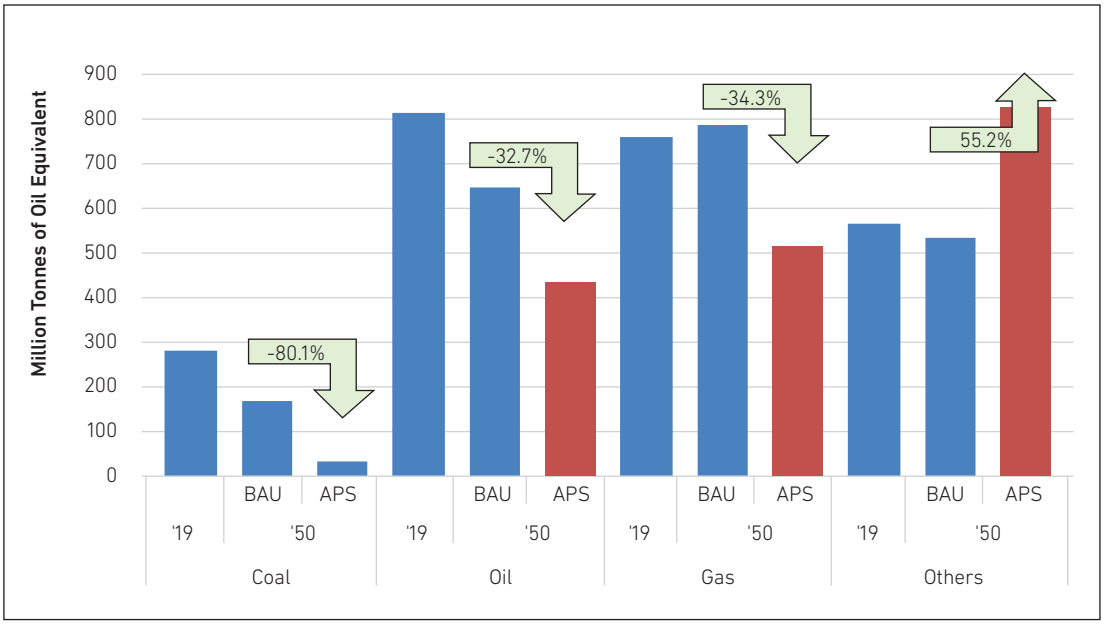



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

Primary energy supply in APS is declines for coal to 32.80 Mtoe. This represents a total energy savings of 132.4 Mtoe (or 80.1%) in 2050 compared with BAU. Oil consumption also declines compared to BAU, with a potential savings of 206.6 Mtoe (or 32.7%) by 2050, while natural gas sees an even more pronounced decline at 263.0 (or 34.3%). In contrast, the combined demand for all others increases by about 286.98 Mtoe (55.2%) compared to BAU in 2050 (Figure 18.8).

**Figure 18.8 Total Primary Energy Supply by Fuel, Business-As-Usual vs. Alternative Policy Scenario, 2019 and 2050**
(Mtoe)




APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

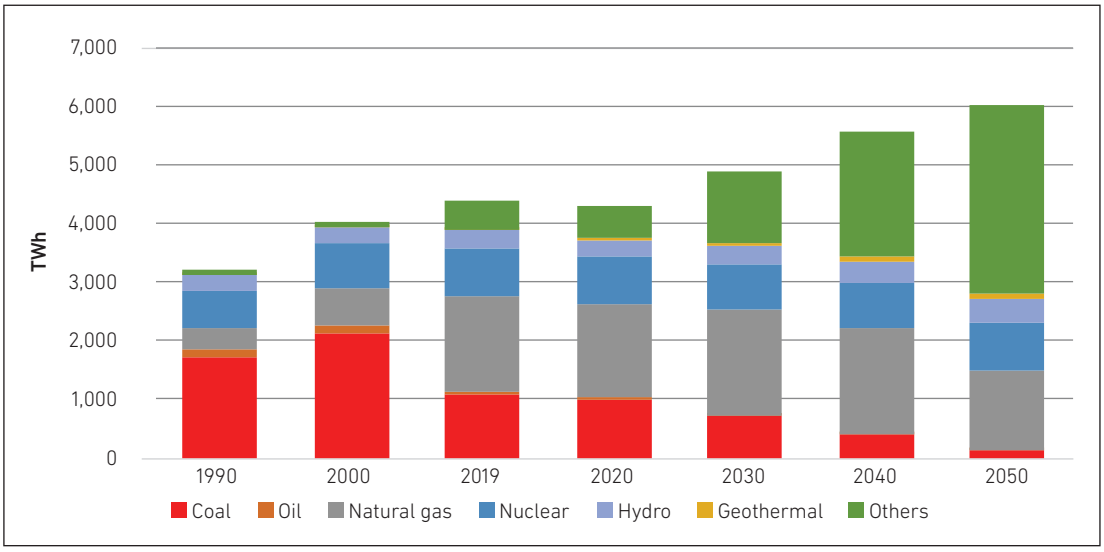
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

### 3.2.3. Power Generation

In line with rising demand for electricity, power generation under the APS rises to 5,997.37 TWh in 2050, an increase of 362.97 (or 6.4%) over BAU in that same year (Figure 18.9). Yet, this modest increase belies larger changes in the US power mix that occur in this scenario. Critical in this context is that the expectation is for the complete implementation of existing US policies that support more aggressive transition to wind, solar, and geothermal sources through 2050, as well as the country's ability to maintain nuclear energy output at roughly 2019 levels. As a result, zero-carbon energy sources come to account for roughly 75.6% of US electricity generation by 2050. Consequentially, in contrast to BAU, zero-carbon generation replaces both coal- and gas-fired power, such that output from natural gas in 2050 is 960.74 TWh less under APS when compared with BAU for the same year. Even so, at 22.5% of total US power generation output, natural gas still represents a significant share of the power mix in 2050.

**Figure 18.9 Power Generation Under Alternative Policy Scenario, 1990–2050**
(TWh)




TWh = terawatt hour.

Note: 'Others' includes residential and commercial sectors.

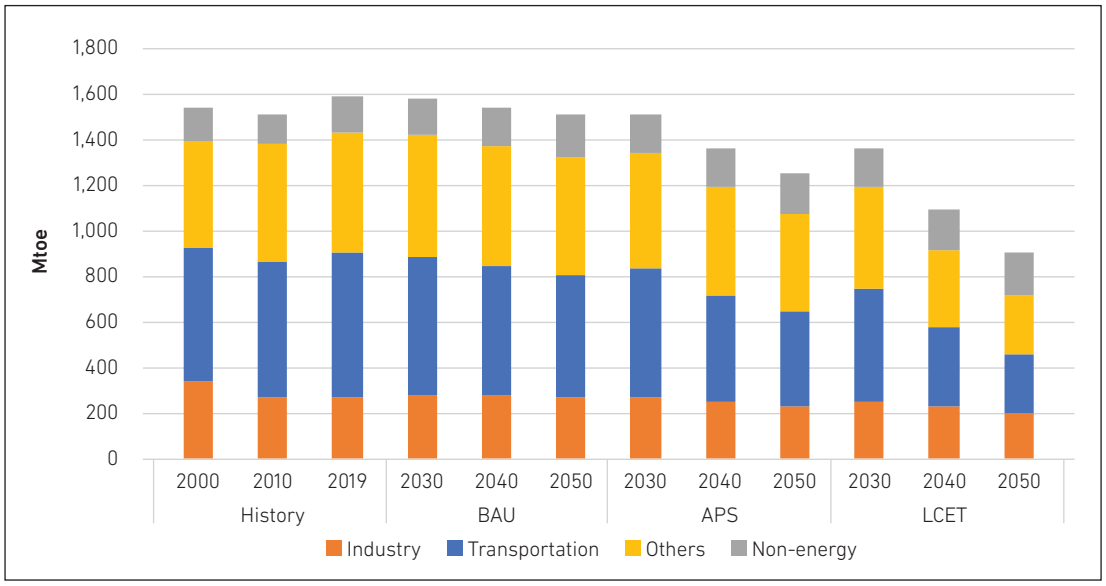
Source: Authors' calculation.

## 3.3. Low Carbon Energy Transition Scenario

### 3.3.1. Final Energy Consumption

Under the LCET scenario, final energy consumption falls from 1,588.48 Mtoe to 901.25 Mtoe during 2019–2050. This suggests that in 2050, there is an additional 350.18 Mtoe (or 28%) savings compared to the APS. Residential and commercial ('others') sectors is now 163 Mtoe (38.5%) lower than the APS, while transport also realises an additional savings of 152 Mtoe (36.5%). Although the savings under the LCET relative to the APS is less pronounced for industry, it is nonetheless notable at an additional decline of 35 Mtoe (15.3%) (Figure 18.10).

**Figure 18.10 Final Energy Consumption by Sector in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050**
(Mtoe)

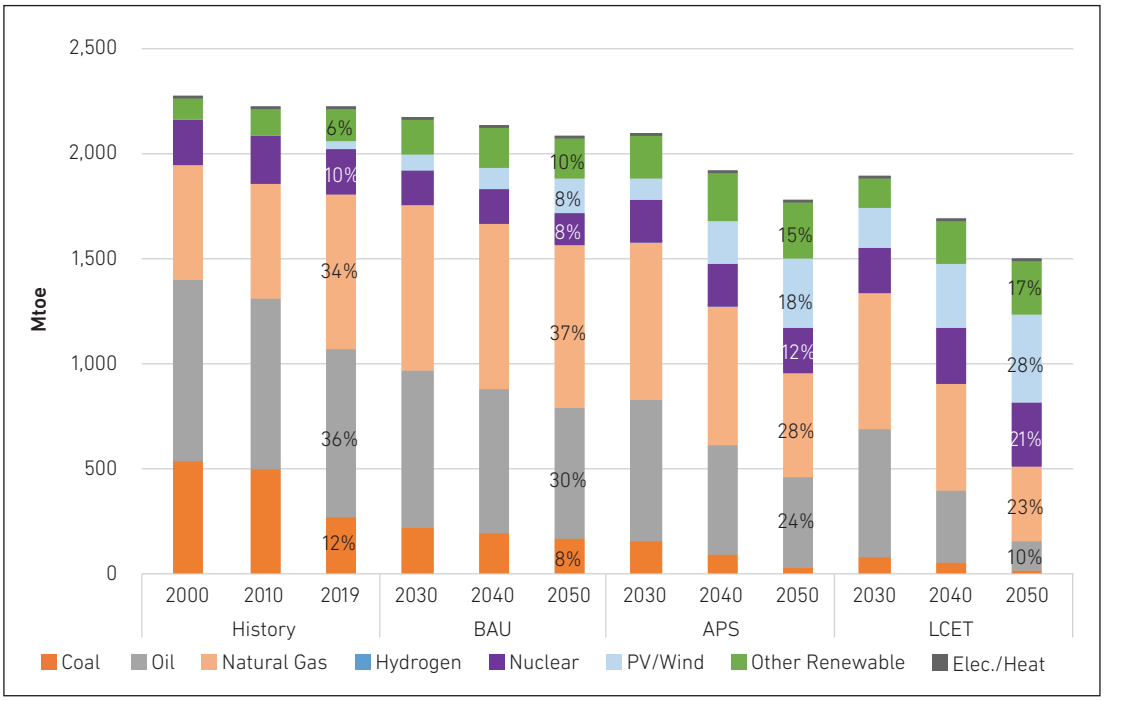



APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.
Note: 'Others' includes residential and commercial sectors.
Source: Authors' calculation.

## 3.3.2. Primary Energy Supply

Under the LCET, the United States' primary energy supply is anticipated to decrease from 2,212.75 Mtoe in 2019 to 1,499.98 Mtoe in 2050. This implies that in 2050, under LCET savings of primary energy supply will be around 268 Mtoe (15% lower) compared with APS (Figure 18-11). As part of this, primary energy supply for coal declines to 18.96 Mtoe. This represents an additional energy saving of 13.84 Mtoe (or 42%) in 2050 over the already dramatic decline in APS. Oil consumption is also anticipated to decline compared to APS, with a potential saving of 281.46 Mtoe (or 66%) by 2050, while natural gas declines by 158.78 Mtoe (or 32%). Meanwhile, demand for all others is anticipated to increase in both absolute terms and relative to APS, with hydrogen/ammonia also playing a growing role.

**Figure 18.11 Primary Energy Supply in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition**
(Mtoe)



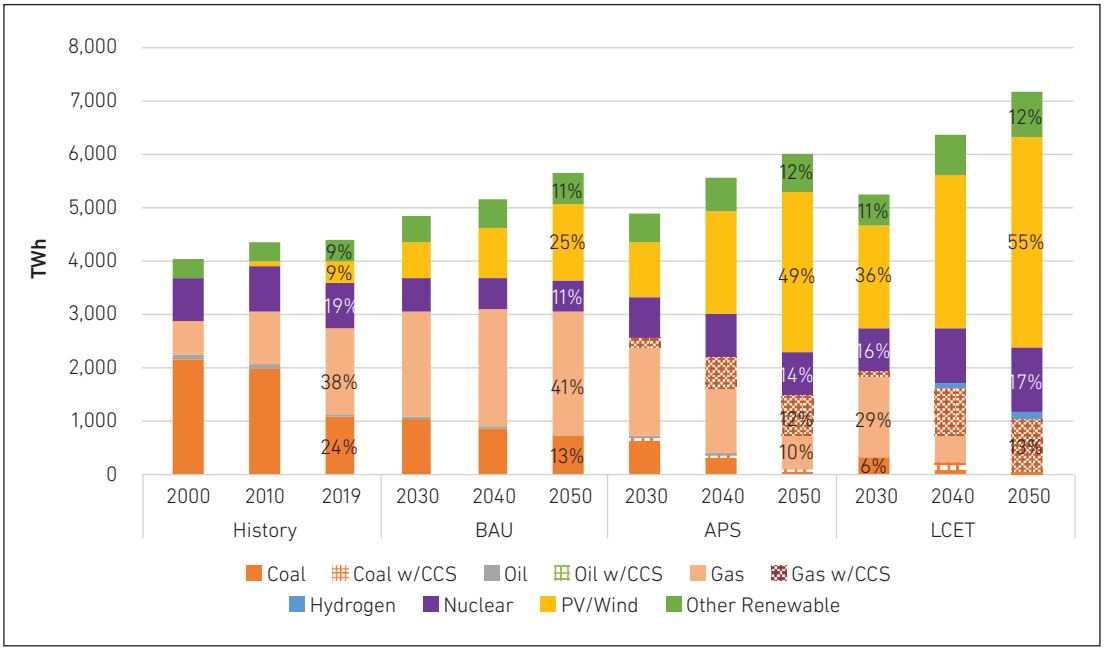

APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent, PV = photovoltaic.

Source: Authors' calculation.

### 3.3.3. Power Generation

The LCET expects even greater progress in electrifying the US economy and an aggressive expansion infrastructure to meet the increased demand. As a result, this scenario sees a significant increase in power generation output, exceeding the APS by 1,176.6 TWh, accounting for nearly 20% of the difference (Figure 18.12).

**Figure 18.12 Power Generation in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000, 2010, and 2019**
(TWh)




APS = alternative policy scenario, BAU = business-as-usual, CCS = carbon capture and storage, LCET = low carbon energy transition, PV = photovoltaic, TWh = terawatt hour.

Source: Authors' calculation.

Under the LCET scenario, a key assumption is that market and policy breakthroughs will make technologies that support the decarbonisation of coal and natural gas more attractive. By 2050, all coal and natural gas are expected to be paired with CCS. However, non-fossil sources remain highly competitive, capturing an even larger share of total power generation output in 2050 compared to the APS. Notably, there is significant growth in wind and solar power and an increase in nuclear power generation due to anticipated technological advancements and new construction. Meanwhile, the collective impact of these various trends leads to a scenario where virtually all US power generation output is fully decarbonised in 2050.

## 3.4. Carbon Dioxide Emissions

All scenarios in this report project that US $CO_2$ emissions will decline during the outlook period, although at markedly different rates. Under BAU, CO2 emissions from energy consumption declines at an annual average rate of 0.7%, from 4,743.6 Mt-C in 2019 to 3,826.6 Mt-C in 2050. This decline is a result of reduced energy consumption overall and ongoing shifts in the US power sector. Specifically, there have been decreases in coal consumption and increases in the consumption of non-fossil sources. However, a decline in nuclear energy generation offsets what might otherwise be even steeper reductions in the power sector.

In the APS, $CO_2$ emissions decrease at an average annual rate of 3% from 4,743.6 Mt-C in 2017 to 1,838.6 Mt-C in 2050. Emissions savings in the APS are thus 51.95% compared to the BAU in 2050. The most dramatic shifts between BAU and the APS are due to absolute reductions in emissions from natural gas (by 836.7 Mt-C), though significant reductions are also seen with coal at 577.9 Mt-C and oil at 573.3 Mt-C. However, persistent uncertainties in investments and progress towards improving aging grid infrastructure, which is necessary to effectively integrate variable renewable energy sources, are likely to pose challenges in achieving new zero-carbon generation capacity online in ways that maximise potential energy savings and $CO_2$ reductions.

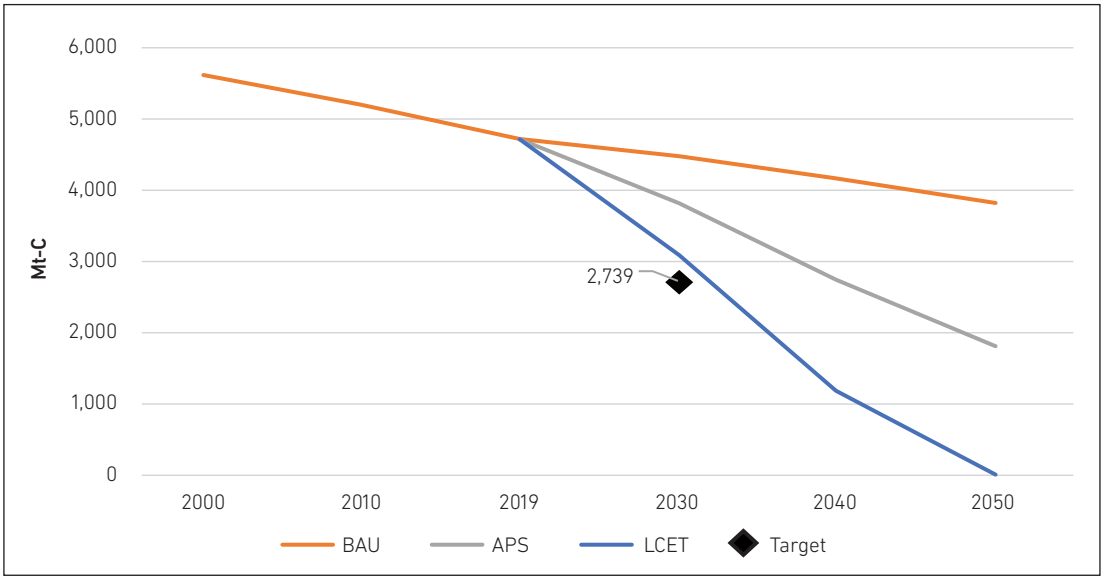
In the LCET, $CO_2$ emissions are anticipated to decrease at an average annual rate of 15.4%, which is five times faster than in the APS and roughly 22 times faster than BAU. However, the rate of decrease does not ensure that the energy system is truly "carbon neutral" by 2050, as roughly 26.2 Mt-C is still emitted annually in this scenario. Key to this picture is substantial emissions that persist from natural gas, which make up roughly 75% of the remaining emissions, as well as emissions from coal. Despite expectations for continued oil consumption in the United States, emissions from oil do reach zero by mid-century in this scenario. This suggests the enormous potential of various tools to support cleaner consumption of this fossil fuel when well-aligned with other decarbonisation efforts.

The United States pledged in its revised Intended National Determined Contribution submission to reduce its greenhouse gas emissions by 50%–52% from 2005 levels by 2030 and reach "net-zero" emissions by 2050.[1] The modelling suggests that the US is making encouraging progress in taming its emissions and, under the APS, could be poised to see even more rapid decline in the future. However, even under the APS more robust action may be necessary to meet the 2030 targets, let alone the goals for mid-century (Figure 18.13). Meanwhile, while the LCET scenario suggests ways that the country might be able to close the gap with its 2030 targets, it nonetheless falls slightly short of guaranteeing that the United States will fully decarbonise its energy system by 2050. Consequentially, even this more aggressive approach suggests that more work remains to be done.

[1] For more on this, see US Department of State and the United States Executive Office of the President, 'The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050,' Washington, D.C, November 2021, https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf (accessed September 1, 2022).

**Figure 18.13** Carbon Dioxide Emission Trends in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050

(Mt-C)




APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Authors' calculation.

# 4. Implications

- While natural gas will remain the single greatest share of the US electricity generation mix over the period to 2050 under BAU, non-hydro renewables such as wind and solar are anticipated to experience the largest growth rates. Further, under the APS and LCET scenarios, zero-carbon sources surpass natural gas as the single greatest share of the US electricity generation mix. Yet, to sustain this shift, it is crucial to increase focus on addressing aging infrastructure and advancing new breakthroughs in storage technologies.
- All scenarios recognise the importance of strengthening the transport sector as a critical opportunity to save energy. This involves not only accelerating the deployment of electric vehicles but also greater attention to fuel efficiency and cleaner consumption technologies. Hydrogen, too, has a potentially prominent role to play.
- Even amidst the changes above, oil and natural gas represent a sizeable share of the United States' energy mix in both BAU and the APS and are still relatively prominent under the LCET. Achieving "net-zero" by 2050 requires radical decarbonisation of their consumption, alongside the transition to renewable and alternative energy sources. Taking the lead in these efforts could also bolster the long-term competitiveness of US fossil fuel exports and contribute to Asia's energy and environmental security goals.
- As referenced above, during the final stages of this report, the United States passed the 2022 Inflation Reduction Act, which incorporates new resources for advancing various clean energy technologies and addressing other concerns mentioned previously. While the specific impacts of this policy on US energy outlooks is a subject for future editions of this study, a key question for the United States now is how to enhance its coordination with allies and partners in operationalising this legislation. This includes how to best address concerns raised by Asian economies regarding its potential impact on their own industries and energy-saving strategies. Such collaboration could create new opportunities to accelerate US emission reductions and yield greater regional benefits.

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