Chapter 17
United States Country Report[1]

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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. As of 2023, it was home to approximately 333.5 million people, of which more than 80% live in urban areas (US Census Bureau, n.d.; World Bank, 2024a).

The US is the world's first or second largest economy (depending on the metric), with a gross domestic product (GDP) of $25.44 trillion and per capita income of $77,950 as of 2022 (World Bank, 2024b, 2024c). By sector of origin, roughly 77% of the US gross domestic product (GDP) can be linked to services, whilst around 18% is linked to industry including construction (World Bank, 2024d, 2024e). Agriculture, forestry, and fishing collectively make up just 1% (World Bank, 2024f). More broadly, international trade also plays a crucial role in the overall strength and health of the US economy, with data from the World Bank suggesting that roughly one-quarter of US GDP is linked to trade (World Bank, 2024g).

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. To that end, in 1990 US 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 2 decades (reaching 1,588.48 Mtoe in 2019).

In terms of how the United States might meet its demand for energy, the country has long had abundant, diverse resource potential, including substantial natural endowments in fossil fuels such as coal, oil, and natural gas; geothermal and hydroelectric potential; and good conditions for wind and solar energy. Yet up until recently, significant portions of this

[1] Unless otherwise cited, all data in this report can be attributed to the Institute of Energy Economics Japan's economic modelling results for the United States, which are included in full as an appendix to this publication.

potential were not considered technically or economically viable; coal alone thus often accounted for a sizeable share of all domestic energy production on an annual basis until well into the early 2000s. However, since then, breakthroughs in technology, declining production costs, and generally favourable environments for development and investment have contributed to a surge of interest in domestic oil, natural gas, and wind and solar energy production. Consequentially, US natural gas production has roughly doubled since 2005, as has domestic crude oil production (US EIA, 2022a). Meanwhile, in the past 10 years alone, US wind power capacity has more than doubled – whilst solar power capacity has increased twentyfold (US EIA, 2022b).

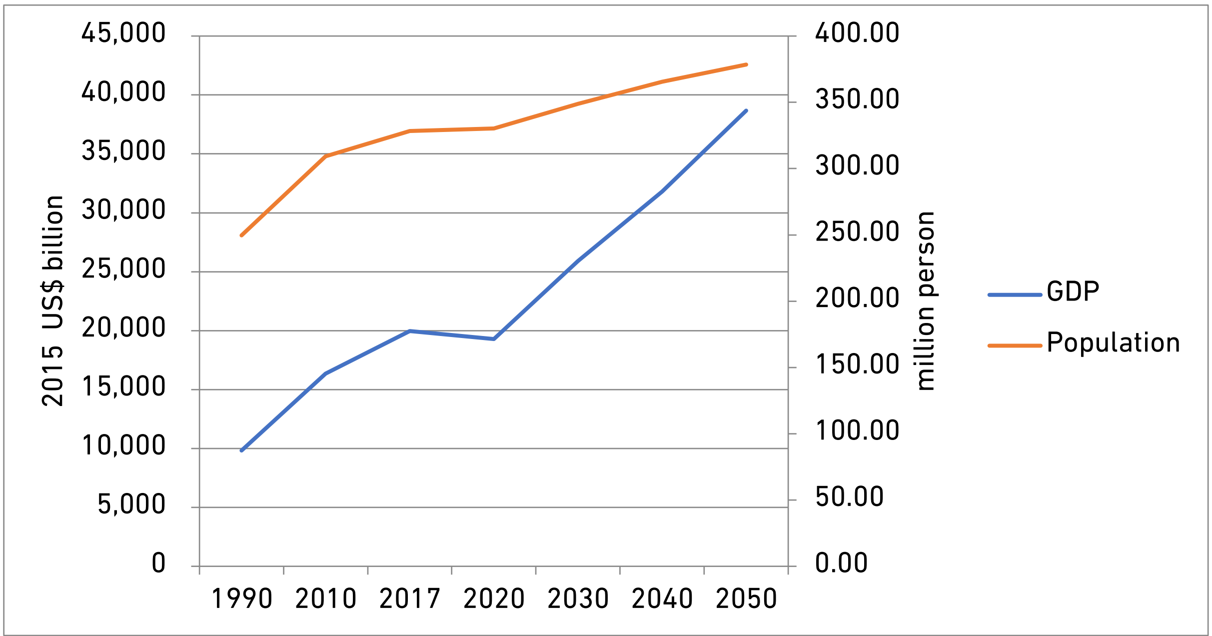
Such developments have had at least two ripple effects on the US energy outlook. The first is accelerating the United States' ongoing shift towards cleaner consumption patterns, given the now wider range of available lower- and zero-carbon supply options. To that end, in 2014 natural gas surpassed coal 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 EIA, 2022c, 2022d, Gillispie, 2022). Collectively, these shifts have also had a knock-on effect of offsetting otherwise anticipated growth in US carbon dioxide (CO_2) emissions – such that, despite the rise in total final energy consumption since 1990, CO_2 emissions in 2019 were only 0.1 million tonnes of carbon (Mt-C) higher than levels in 1990 (i.e. 1,293.6 Mt-C vs. 1,293.7 Mt-C).

The second major impact of these shifts is in reshaping the United States' otherwise expected outlook for trade in energy. Increased US oil and natural gas production has contributed to not only backing out US requirements for relevant Canadian and other imports, but also bolstered the country's potential to serve as an important global energy supplier. This includes as a supplier of natural gas where, as of 2023, notable volumes of US liquefied natural gas exports have already been delivered to Japan, Taiwan, India, the Republic of Korea, and China (US EIA, 2022e). Meanwhile, reduced requirements for coal at home has also translated into a greater emphasis on export markets for US coal producers, with India, Japan, and the Republic of Korea accounting for three of the US' top five steam coal export markets (US EIA, 2022f). Whilst these trends suggest a number of ways in which US energy production might be able to contribute to regional energy security outlooks—not to mention to US trade balances – several factors may nonetheless curtail interest in otherwise available US supplies and technologies. These include potential bottlenecks in relevant energy export and import infrastructure as well as intense competition between the United States and other economies for global market share – all amidst rising domestic and global concerns around climate change.

2. Modelling Assumptions

Over this study's outlook period of 2019–2050, both overall 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 17.1). Whilst 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 17.1. Gross Domestic Product and Population



GDP = gross domestic product.
Source: Authors' calculations.

Between 1990 and 2019, the United States' GDP grew at an average annual rate of 2.5%. Despite significant disruption during the 2007–2008 global economic crisis and once again during the 2020–2021 novel coronavirus disease (COVID-19) crisis, the US economy has generally been able to realise steady (albeit relatively modest) growth.[2] Hence, this model projects that the US GDP growth rates will re-stabilise over the outlook period at an annual average growth rate of 2.2% per year. This estimate aligns with expectations of continued efficiency and productivity gains coupled with modest yet sustained population growth. It also assumes continued US leadership on innovation and strong global industrial competitiveness.

[2] For more on this, see Gillispie (2022).

With these conditions in mind, this study estimates the US' energy saving and CO_2 emissions reduction potential as well as select costs of such shifts by comparing the results of a business as usual (BAU) scenario with the cumulative impact of several alternative policy (AP) scenario and a low-carbon energy transition (LCET–CN) scenario. In the BAU scenario, numerous longstanding market trends are expected to continue to hold true. Such trends include weakening outlooks for coal and nuclear energy, given unfavourable economics and social license in the United States when compared with non-hydro renewables and natural gas. Coal in particular is expected to undergo a dramatic decline, given the growing market competitiveness of alternative generation options (as described above) as well as the expected retirement of a number of older, less efficient coal-fired plants during the outlook period. Meanwhile, despite a projected uptick in the use of alternative fuels and in the pace of electric vehicle adoption, the US transport sector is also anticipated to remain heavily reliant on oil in this scenario – at least in part due to relatively more modest means and incentives for sparking large-scale switching when compared with the tools available within the power sector.

The AP scenario, in contrast, examines what a country's energy outlook might look like assuming the full implementation and realisation of a range of policy efforts that are already underway as of 2022. This includes greater progress in established efforts to strengthen efficiency of final energy demand; improve efficient thermal power generation; sustain a robust role for nuclear energy as a source of baseload power generation; and realise a higher contribution from renewable energy in total supply. For the United States, calculations here are modelled based on a review and assessment of US laws and policies in place at the national- and state-level 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 the AP scenario findings.

Finally, the LCET–CN scenario models what shifts (if any) might enable a country to reach net-zero CO_2 emissions on an annual basis by 2050. In the case of the United States, such shifts include the adoption of specific new incentives, tools, and approaches that are more aggressive in prioritising decarbonisation than those in the AP scenario but that nonetheless remain technically feasible and at least *potentially* socially acceptable.[3] Here, the United States' *Pathways to Net-Zero Greenhouse Gas Emissions by 2050* serves an important basis for such scenario modelling, as do the various executive orders issued by the Biden administration related to decarbonising power-, transport-, and industry-sector energy demand. However, in some cases, divergences between the findings of these official reviews and this report do occur, given modest differences in methodologies (including assumptions about likely economic conditions and technological advances between 2019 and 2050).

[3] E.g. more aggressive dates for phasing out combustion engines, but not the suggestion of eliminating all motorised vehicles.

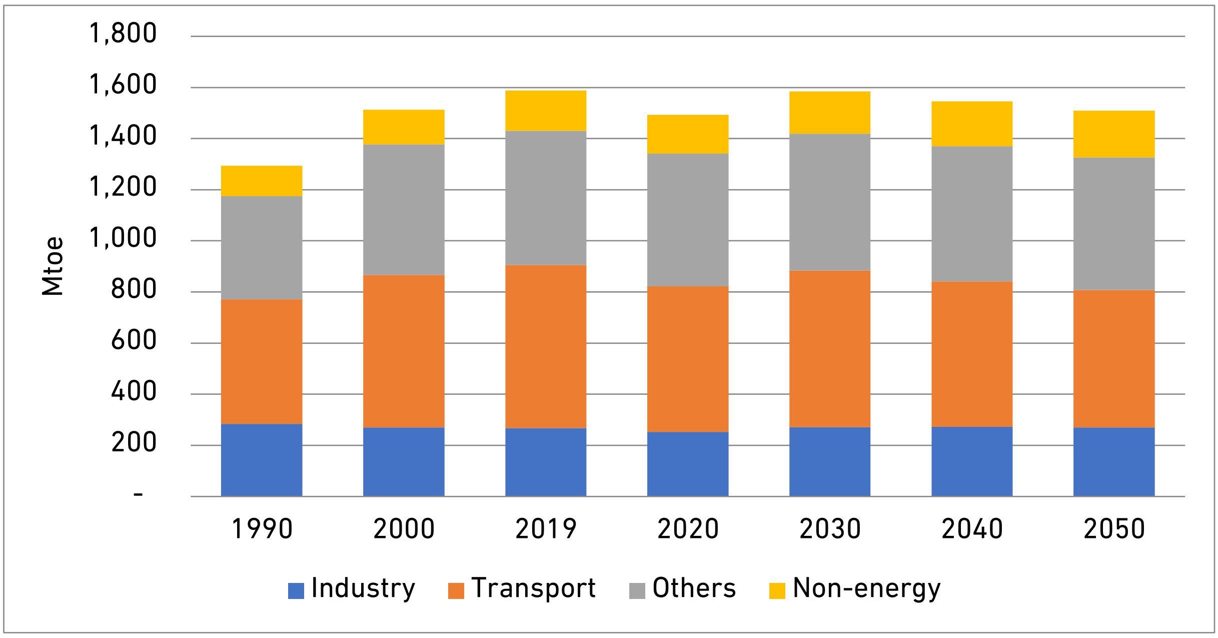
3. Outlook Results

3.1. Business as Usual Scenario

Final Energy Consumption

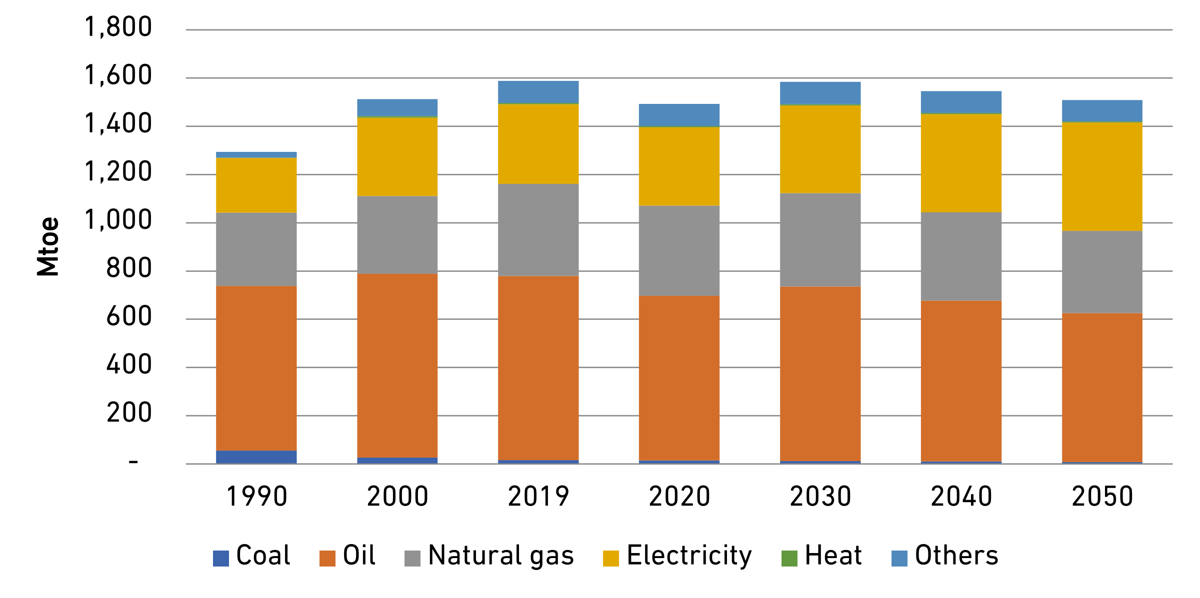
Under the BAU scenario, total final energy consumption is anticipated to decline slightly between 2019 and 2050, at an average annual rate of decrease of 0.2% (Figure 17.2). The transport sector is a key driver of this decline, as otherwise expected growth linked to a modest rise in vehicle ownership 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 total US energy consumption is offset by a rise in non-energy sector consumption, which is expected to see average annual growth of 0.5%. Meanwhile, both industry and others are expected to see relatively flat growth during the outlook period.

Figure 17.2. Final Energy Consumption by Sector under BAU Scenario



BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

Figure 17.3. Final Energy Consumption by Fuel Type under BAU Scenario



BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

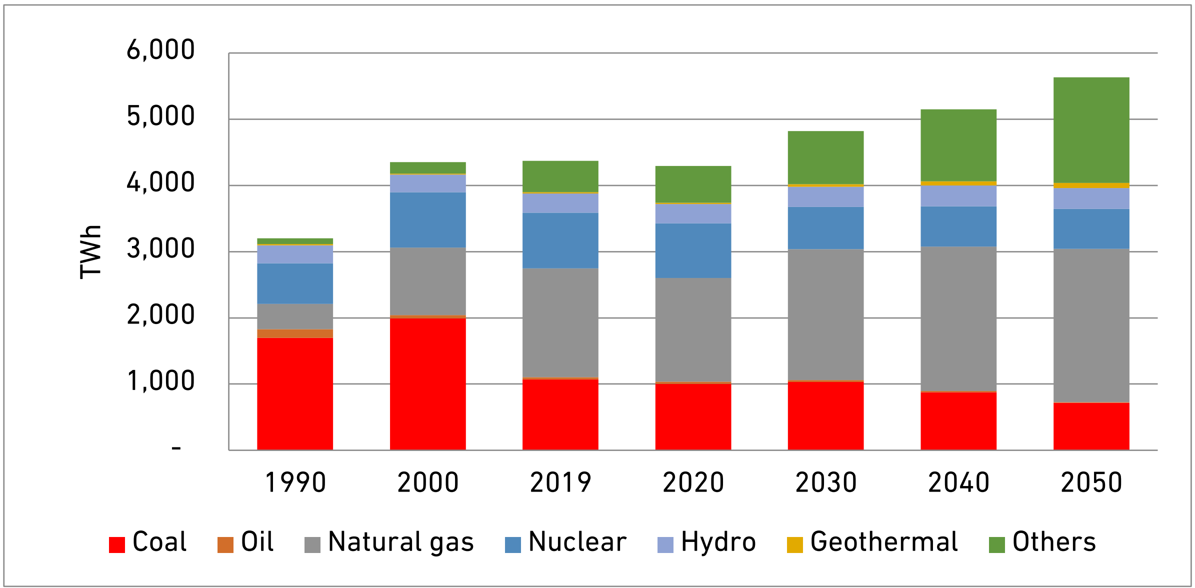
In this context, oil consumption declines and by 2050, is anticipated to fall to 616.91 Mtoe (roughly 10% below levels in 1990). Coal consumption also declines and does so consistently throughout the entire 2019–2050 period. In contrast, electricity consumption grows (from 329.32 Mtoe in 2019 to 448.68 Mtoe in 2050), which (amongst other things) reflects headwinds in newly electrifying various sectors of the US economy (e.g. transport as well as industry). Natural gas consumption likewise grows overall but shows signs of a potential peak and then subsequent decline after 2030 as the fuel faces additional competition from other energy types in multiple end-use sectors.

Primary Energy Consumption

Under the BAU scenario, total primary energy consumption 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, whilst nuclear declines by 1.1%. In contrast, non-hydropower renewables experience the largest growth in consumption this period at 4.8%, followed by geothermal at 4.6%.

Power Generation

Figure 17.4. Power Generation under the BAU Scenario



BAU = business as usual, TWh = terawatt-hour.
Source: Authors' calculations.

Electricity generation in the United States, under BAU, is project to increase over the outlook period, although at a modestly slower pace than the previous 25 years. Generation output increases from 4,370.99 terawatt-hours (TWh) to 5,634.40 TWh between 2019 and 2050 (Figure 17.4), for an average annual growth rate (AAGR) of 0.8%. The retirement of older, less efficient coal-fired plants, as well as ongoing technological improvements promoting more efficient consumption are assumed to play important roles in shaping this outlook, alongside broader market and policy forces that incentivise input switching. In line with this, coal declines steadily – at 1.3% a year – and by 2050 is anticipated to account for only 12.7% of all US power generation (down from 24.5% in 2019). Meanwhile, natural gas is expected to gain 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 US power generation output may come from zero-carbon energy sources.

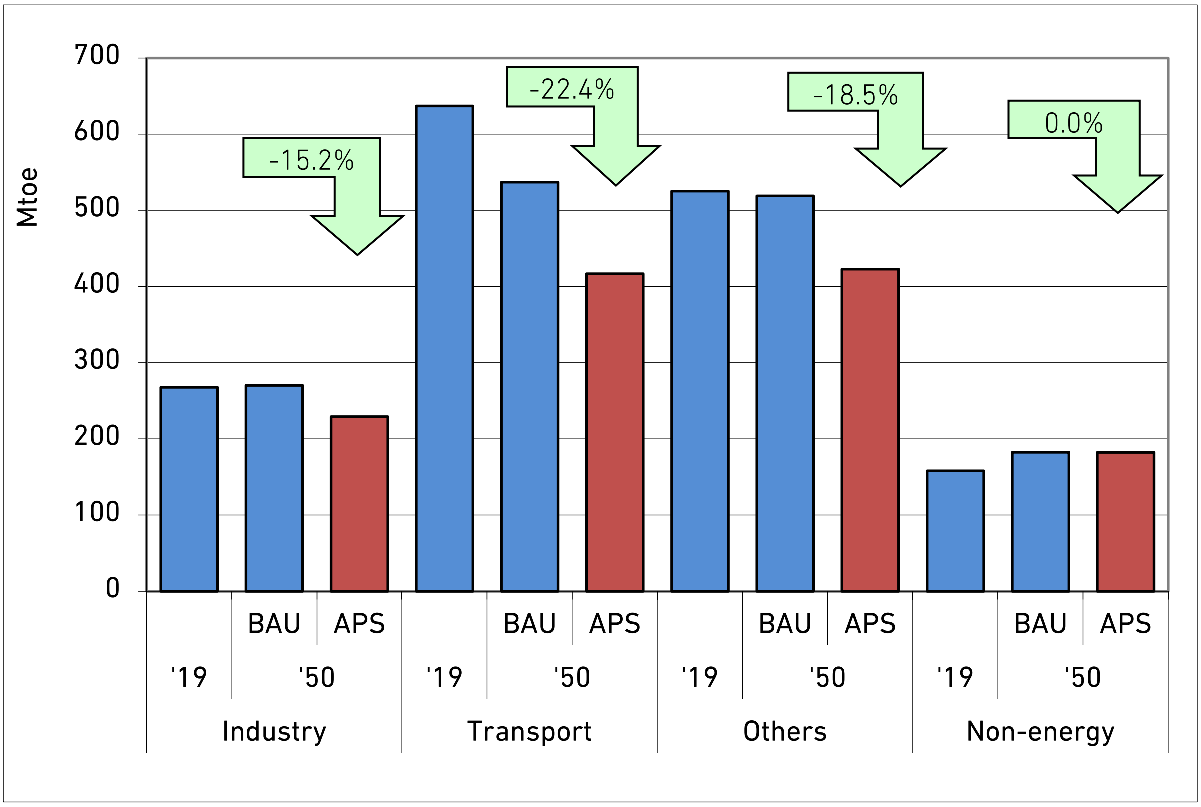
3.2. Alternate Policy Scenario

Final Energy Consumption

Under the AP scenario, this study projects that an even more dramatic decline in total final energy consumption will occur in the United States. To that end, under the AP scenario such consumption is expected to decline from 1,588.48 Mtoe to 1,251.43 Mtoe during the 2019–2050 period. When compared with the BAU scenario, this shows an energy savings of roughly 258 Mtoe or 17.1% during the outlook period. Transport realises a saving of 120 Mtoe (22.4%), industry saves 41 Mtoe (15.2%), and residential and commercial (others) saves 96 Mtoe (18.5%) (Figure 17.5). Meanwhile, in contrast to expectations under BAU, both industry *and* residential and commercial now realise some level of declining overall consumption.

The impacts of this decline are not evenly distributed across fuel type. Whilst coal, oil, and natural gas all realise even faster rates of decline over the outlook period under the AP scenario, the difference between the AP and BAU scenarios is sharpest for natural gas. Meanwhile, electricity consumption is still anticipated to grow – and, indeed, is modestly higher than in BAU – given factors such as an increased uptake in electric vehicles.

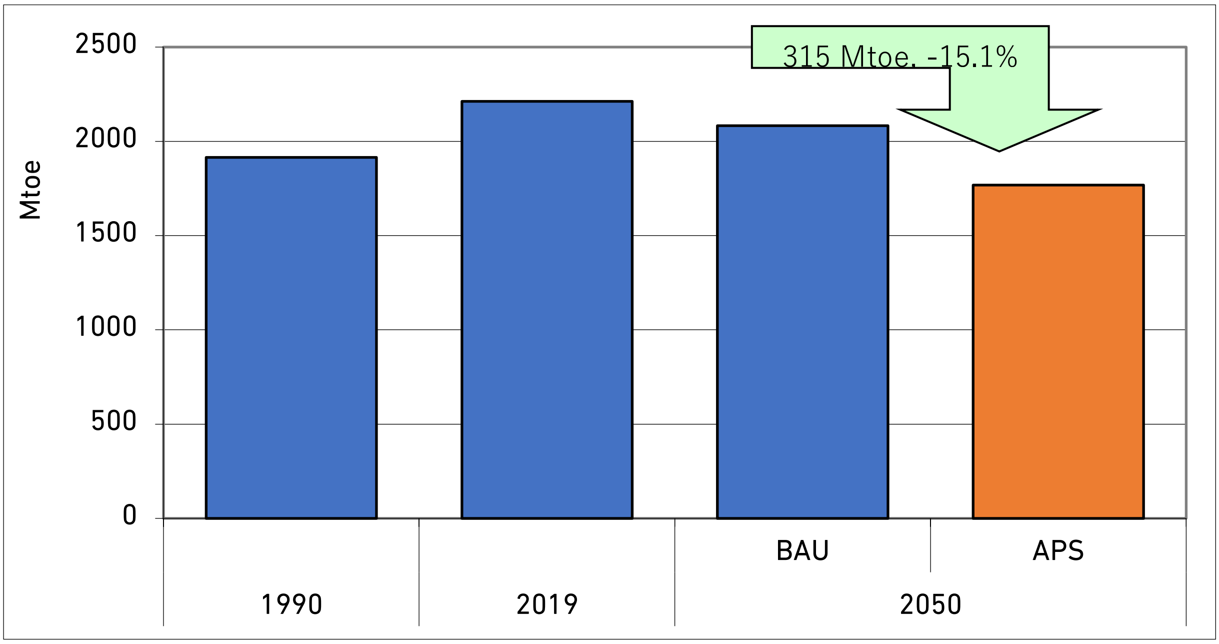
Figure 17.5. Final Energy Consumption by Sector in BAU vs. AP Scenarios



AP = alternative policy, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

Primary Energy Consumption

Figure 17.6. Total Primary Energy Consumption in BAU vs. AP Scenarios

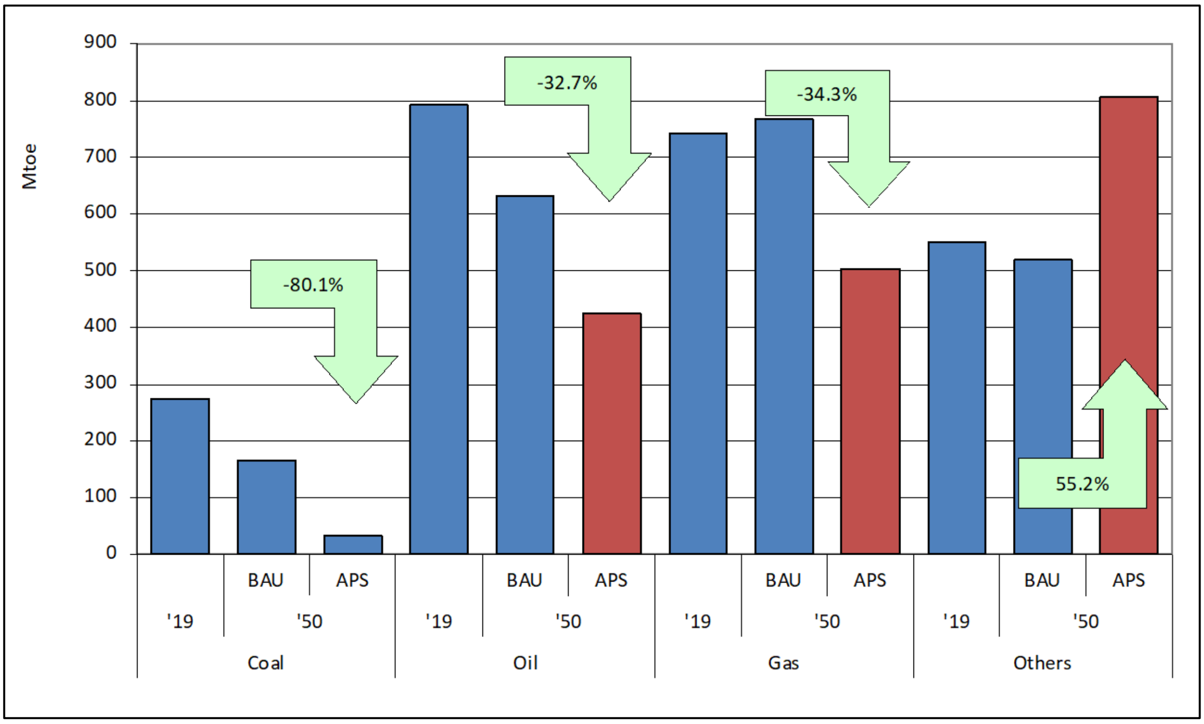


AP = alternative policy, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

Under the AP scenario, the United States' primary energy consumption is anticipated to decrease from 2,212.75 Mtoe in 2019 to 1,767.98 Mtoe in 2050. This implies that in 2050, primary energy consumption under the AP scenario will be around 315 Mtoe or 15.1% lower than BAU (Figure 17.7).

Primary energy demand in the AP scenario is expected to decline for coal to 32.80 Mtoe. This represents a total energy saving of 132.4 Mtoe (or 80.1%) in 2050 compared with BAU. Oil consumption is also anticipated to decline compared to BAU, with a potential saving of 206.6 Mtoe (or 32.7%) by 2050, whilst natural gas is anticipated to see an even more pronounced level of decline at 263.0 (or 34.3%). In contrast, the combined demand for all others is anticipated to increase about 286.98 Mtoe (55.2%) compared to BAU in 2050.

Figure 17.7. Total Primary Energy Consumption by Fuel in BAU vs. AP Scenarios

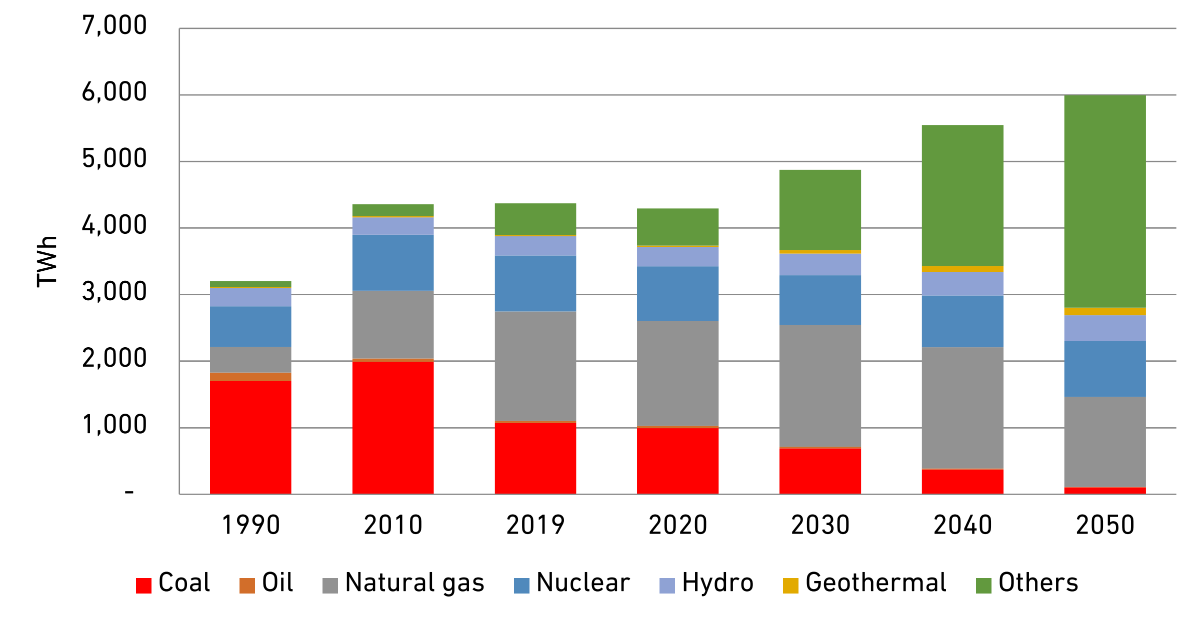


AP = alternative policy, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

Power Generation

In line with rising demand for electricity, power generation under the AP scenario rises to 5,997.37 TWh in 2050 under the AP scenario – an increase of 362.97 (or 6.4%) over BAU in that same year (Figure 17.8). Yet this modest increase belies larger changes in the US power mix that occur in this scenario. Critical in this context is thus expectations that the full implementation of policies already in place as of 2021 supports more aggressive switching to wind, solar, and geothermal sources in the United States through 2050, as well as the country's ability to maintain nuclear energy output at roughly 2019 levels. This, in turn, produces a scenario where zero-carbon energy sources come to account for roughly 75.6% of US electricity generation by 2050. Consequentially, and in contrast to BAU, zero-carbon generation now backs out not just coal- but also 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 of 2050.

Figure 17.8. Power Generation under AP Scenario



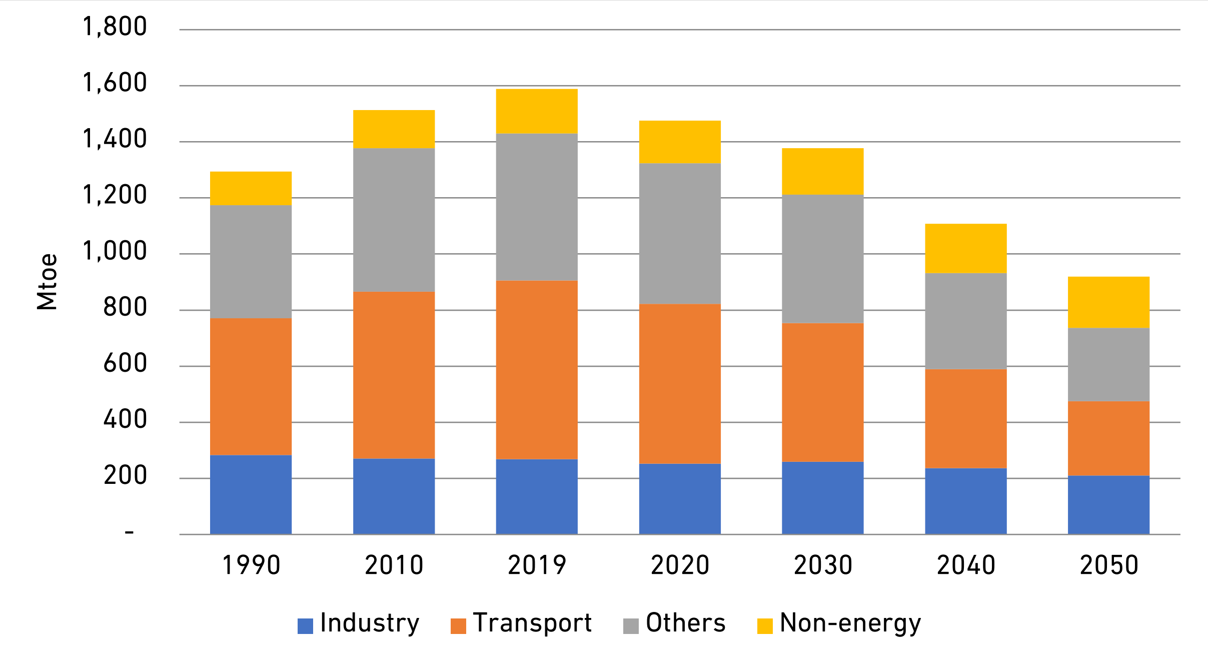
AP = alternative policy, TWh = terawatt-hour.
Source: Authors' calculations.

3.3. Low-carbon Energy Transition Scenario

Final Energy Consumption

Under the LCET–CN scenario, final energy consumption falls from 1,588.48 Mtoe to 918.89 Mtoe during the 2019–2050 period. This suggests a savings in 2050 that is an additional 332.53 Mtoe (or 27%) lower than in the AP scenario – and a full 590.15 Mtoe (or 39%) lower than BAU. Residential and commercial (others) is now 161.36 Mtoe (38.2%) lower than the AP scenario, whilst transport also realises a significant additional saving of 152.24 Mtoe (36.5%). Although the saving under the LCET–CN scenario relative to the AP scenario is less pronounced for industry, it is nonetheless notable at an additional decline of 18.93 Mtoe (8.3%) (Figure 17.9).

Figure 17.9. Final Energy Consumption by Sector



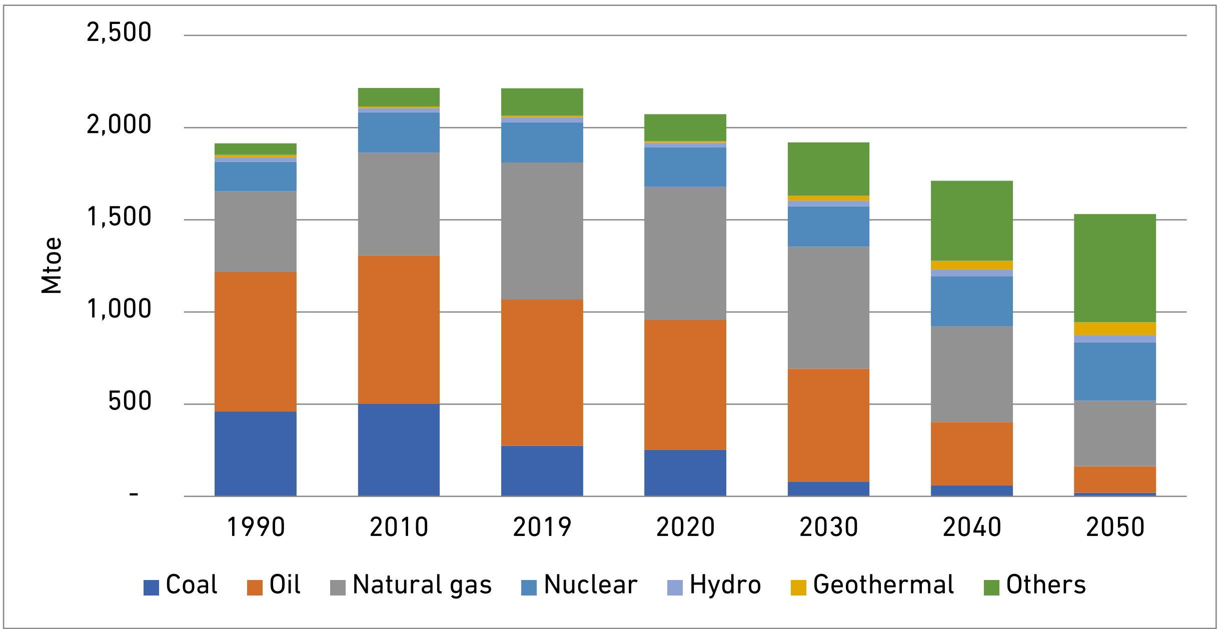
Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

Primary Energy Consumption

Under the LCET–CN scenario, the United States' primary energy consumption is anticipated to decrease from 2,212.75 Mtoe in 2019 to 1,530.65 Mtoe in 2050. This implies that in 2050, under LCET–CN savings of primary energy consumption will be around 237.33 Mtoe (13.4%) lower compared with the AP scenario (Figure 17.10).

As part of this, primary energy demand for coal declines to 19.67 Mtoe. This represents an additional energy saving of 13.13 Mtoe (or 40%) in 2050 over the already dramatic decline in APS. Oil consumption is also anticipated to decline compared to the AP scenario, with a potential saving of 281.14 Mtoe (or 66.2%) by 2050, whilst natural gas declines by 147.71 Mtoe (or 29.3%).

Figure 17.10. Total Primary Energy Supply



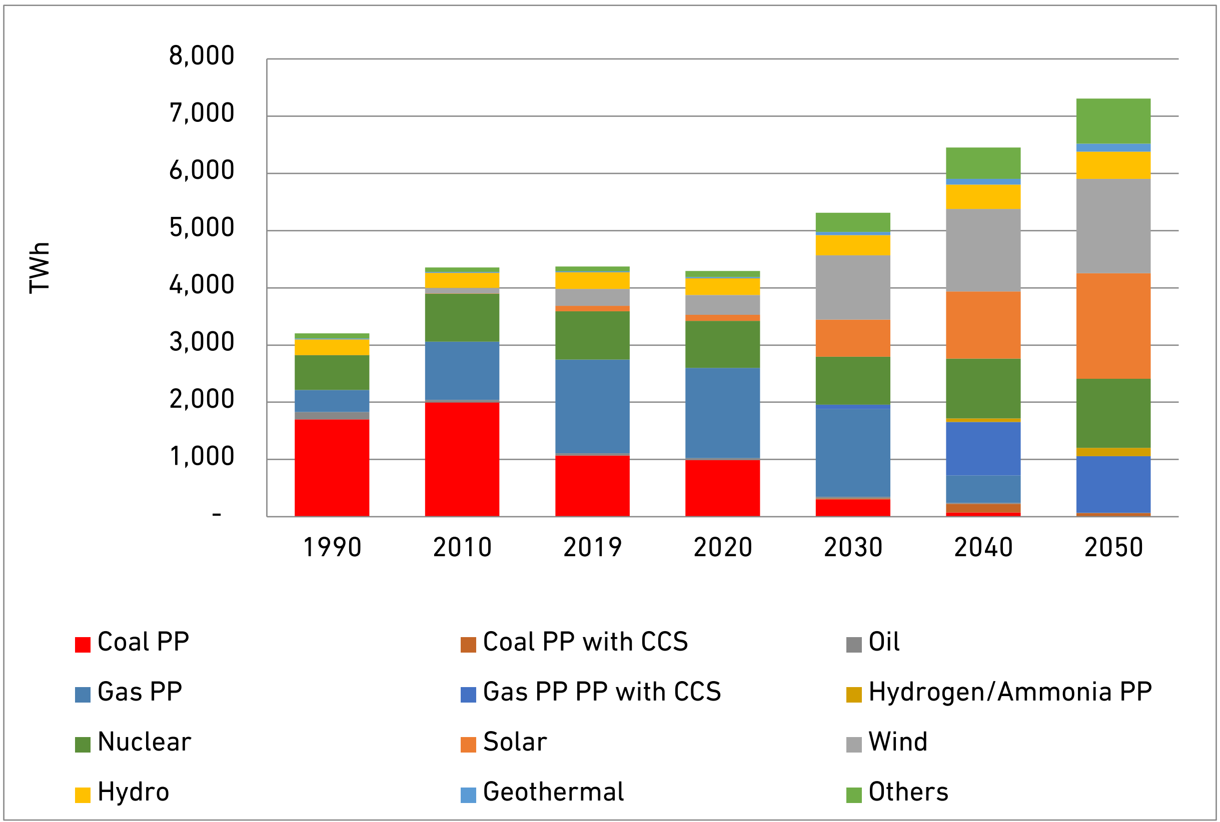
Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

Power Generation

The LCET–CN scenario anticipates even greater progress towards the goal of electrifying the US economy as well as the build-out of relevant infrastructure. Thus, and perhaps not surprisingly, this scenario sees a significant increase in power generation output – by 1,311.08 TWh (or nearly 22%) more than under the AP scenario.

A key assumption under the LCET–CN scenario is that market and policy breakthroughs increase the attractiveness of technologies that support the decarbonisation of coal and natural gas. To that end, in 2050 all generation from coal and from natural gas are now paired with carbon capture and storage (CCS). Even so, non-fossil sources remain highly competitive and capture an even larger share of total power generation output in 2050 under the LCET–CN scenario relative to the AP scenario. Notable here is not only new growth in wind and solar but also an uptick in generation from nuclear power (as a result of both technological breakthroughs and new construction). Meanwhile, the collective impact of these trends is even more pronounced – suggesting a scenario where in 2050, virtually of all US power generation output is fully decarbonised.

Figure 17.11. Power Generation



CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.
Source: Authors' calculations.

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, US CO_2 emissions from energy consumption are anticipated to decline an annual average rate of decrease of 0.7% – going

from 1,293.7 Mt-C in 2019 to 1,043.6 Mt-C in 2050. This level of decline reflects both the decline in total US energy consumption, as well as continued switching in the US power sector – particularly decreases in coal consumption and increases in consumption of non-fossil sources. However, a decline in generation from nuclear energy offsets what might otherwise be even steeper power sector reductions.

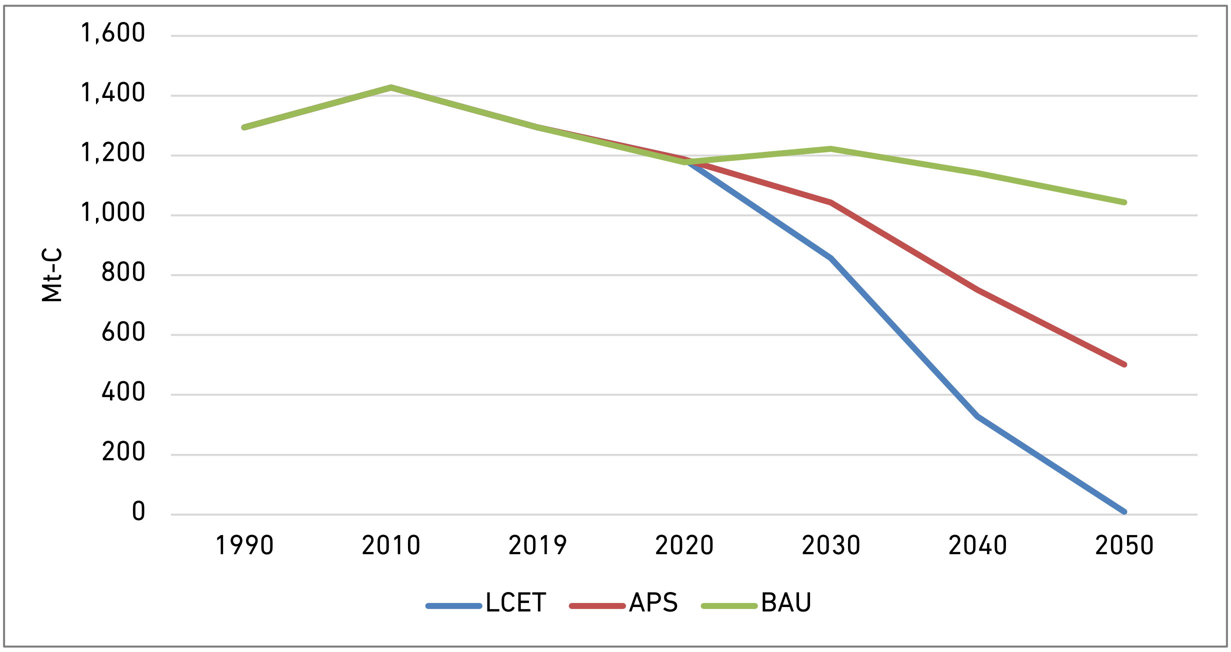
In the AP scenario, CO_2 emissions are projected to decrease at an average annual rate of 3% from 1,293.7 Mt-C in 2019 to 501.4 Mt-C in 2050. Emissions savings in the AP scenario are thus 51.95% compared to the BAU in 2050. The most dramatic shifts between the BAU and AP scenarios link to absolute reductions in emissions from natural gas (an additional 228.2 Mt-C in savings), though both coal and oil also see significant additional new reductions, at a further 157.6 Mt-C and 156.4 Mt-C, respectively. However continued uncertainties in investments and in progress towards strengthening existing, ageing grid infrastructure (so that it can better manage variable renewable energy sources) are likely to continue to challenge efforts to bring new zero-carbon generation capacity online in ways that maximise potential energy savings and CO_2 reductions.

In the LCET–CN scenario, CO_2 emissions are anticipated to decrease at an average annual rate of 14.7% – nearly five times faster than the AP scenario and roughly 21 times faster than BAU. Even so, the rate of decrease does not ensure that the United States' energy system is 'carbon-emission free' by 2050, as roughly 21.8 Mt-C is still emitted annually in this scenario. Key to this picture is lingering emissions from natural gas – which make up over three-quarters of remaining emissions – as well as from coal. Encouraging, though, emissions from oil *do* reach zero by mid-century in this scenario, despite expectations for continued consumption of this fuel in the United States. This suggests the enormous potential of various tools to support cleaner consumption of this fossil fuel when well-aligned with other decarbonisation efforts.

In its revised Intended Nationally Determined Contributions submission, the United States pledged to reduce its greenhouse gas emissions by 50%–52% from 2005 levels by 2030 and to reach net-zero emissions by 2050.[4] The above modelling suggests that the US is already making encouraging progress in taming its emissions and, even under BAU, is likely to see further reductions. However, only under the LCET–CN scenario is the United States anticipated to come close to (although not quite meet) the country's targets for 2030. Meanwhile, the LCET–CN scenario *does* see a pathway for the United States to reach 'carbon neutrality' by 2050 – but only through a combination of both aggressive systemic transformation *and* leveraging bioenergy with carbon capture and storage, carbon sinks, and other tools to deliver 'negative emissions.' As suggested by Figure 17.12, even a relatively modest valuation of US efforts in this space is likely to deliver net-negative emissions by 2050. However, scaling up efforts here is not expected to act as a full- or partial-alternative to the more aggressive transformations of US energy systems that will need to be done.

[4] For more on this, see US Department of State and the United States Executive Office of the President (2021).

Figure 17.12. CO_2 Emissions Trends in BAU, AP, and LCET–CN Scenarios



AP = alternative policy, BAU = business as usual, CO_2 = carbon dioxide, LCET–CN = low-carbon energy transition–carbon neutral, Mt-C = million tonnes of carbon.
Source: Authors' calculations.

3.5. Hydrogen Demand

As of 2019, all three models register US final energy demand for hydrogen at 0 Mtoe. Over the outlook period, neither the BAU nor AP scenarios project any additional US demand for hydrogen. This is largely due to their assumptions that necessary market-creation steps – such as large-scale buildouts of enabling infrastructure and greater harmonisation of various industry standards – are unlikely to occur during this period absent additional, targeted policy support. Thus, even to the extent that hydrogen production costs could come down (another important consideration), the BAU and AP scenarios find wider conditions as continuing to limit hydrogen's competitiveness relative to other fuels and technologies.

The LCET–CN scenario, in contrast, examines what might be possible if some of these initial market conditions could be addressed through enhanced policy support (with key assumptions here including robust coordination amongst both US and international stakeholders, given aims to minimise market fragmentation). With such efforts in place, the LCET–CN scenario sees US demand for hydrogen as well-positioned to take off within the 2020s, reaching 11.03 Mtoe by 2030. Over the next decade, it then continues to increase at an AAGR of 18.9% – reaching 62.10 Mtoe in 2040 – before slowing to an AAGR of 5.6% between 2040 and 2050. The result is that the LCET–CN scenario sees US final energy demand for hydrogen as reaching 106.63 Mtoe in 2050.

Such demand for hydrogen in the LCET–CN scenario is underpinned by usage in multiple sectors. As suggested in Figure 17.11, hydrogen is expected to play a role in US power generation in 2050, albeit a relatively modest one – accounting for only 2% of the overall mix. Hydrogen is also anticipated to play a role in backing out demand for other fuels in both the transport and industry sectors. Ultimately, though, as of this writing in 2024 many US energy strategy documents continue to assume a wide range of potential futures around US final energy demand for hydrogen, given its complex relationship with other elements of net-zero planning. To that end, the US' *Pathways to Net-Zero Greenhouse Gas Emissions by 2050* notes that scenarios that utilise large volumes of hydrogen also see large increases in electricity use (US Department of State and US Executive Office of the President, 2021); something that would then have additional implications for infrastructure and capital investment requirements.

3.6. Energy Cost Comparisons between the BAU and LCET–CN Scenarios

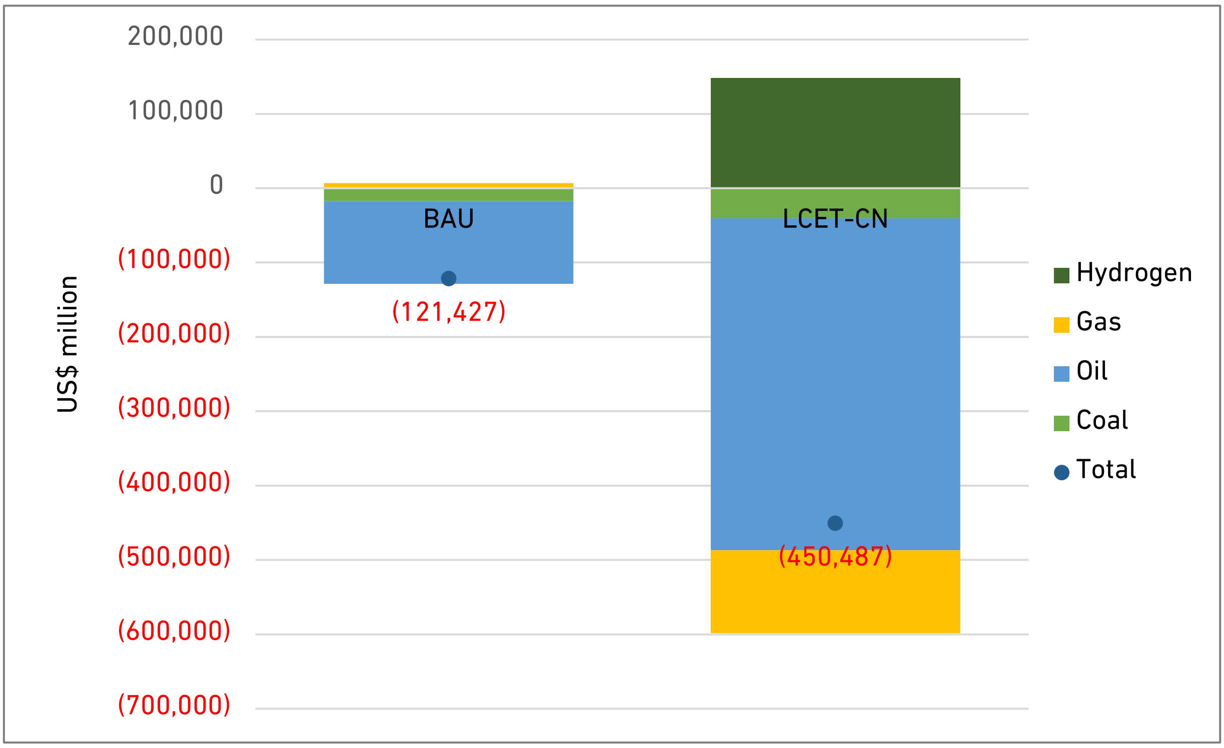
Fuel Costs

Given the scale of US demand for energy generally and for oil, natural gas, and coal specifically, current US spending on fuel is considerable. This study estimates that in 2019 alone, US fuel costs totalled US$803,128 million. Roughly 68% of these costs were connected to oil, whilst natural gas accounting for additional 27%. Meanwhile, coal accounted for roughly 5%.

All scenarios project that US fuel costs will decline over the outlook period – although do so with very different rates. Under BAU, an overall trend of declining oil and coal consumption combined with some modest growth in natural gas consumption supports a decline in fuel costs to US$681,701 million in 2050 (a savings of US$121,427 million, relative to 2019).

Under the LCET–CN scenario, US fuel costs in 2050 are expected to decline to US$253,964 million – US$450,487 million lower than in 2019 and an additional US$329,060 million in savings beyond BAU (Figure 17.13). This is primarily driven by the scenario's steep decline in oil consumption, followed by a (relatively) more modest decline in natural gas. Alongside this, although the LCET–CN scenario does envision that US spending on hydrogen will grow sharply over the outlook period, reaching $148,015 million a year in 2050. In contrast, US spending on hydrogen in 2050 under BAU is zero, given the absence of demand for this fuel in that scenario. Even so, US spending on hydrogen in 2050 under the LCET–CN scenario is equivalent to only 69% of US spending on natural gas in just 2019.

Figure 17.13. Fuel Costs Savings in 2050 in BAU vs. LCET–CN Scenarios

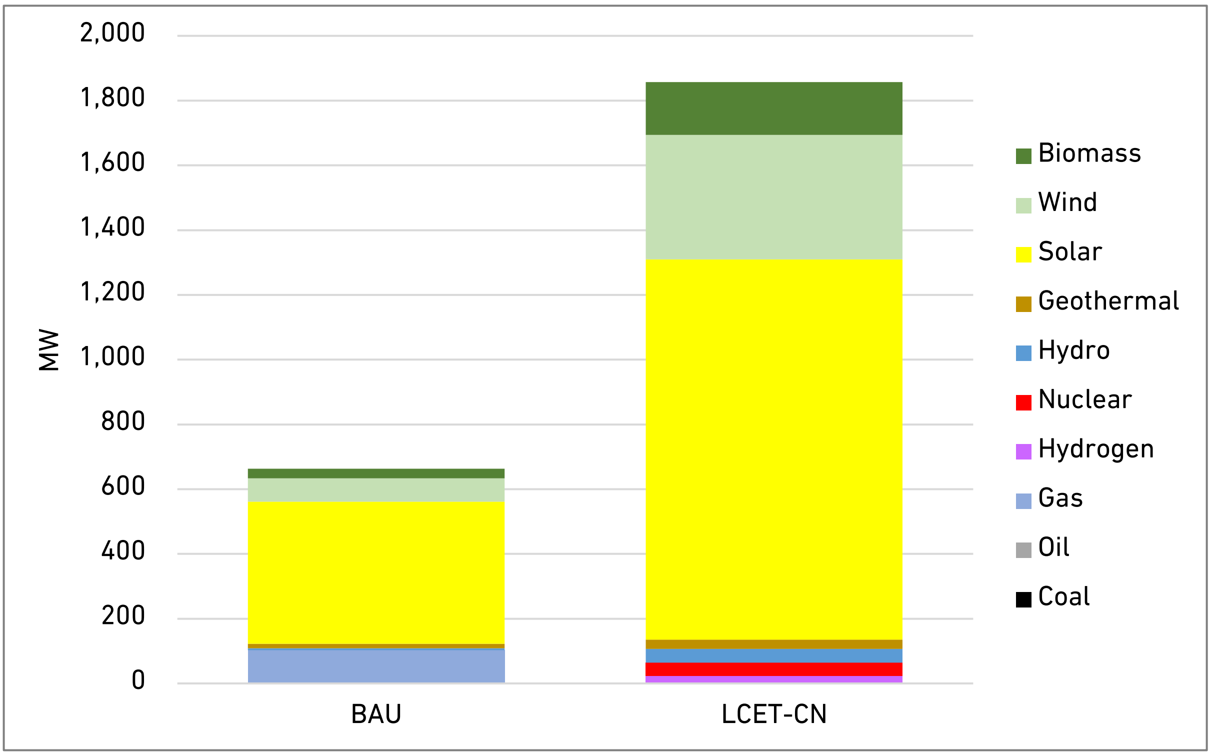


BAU = business as usual, LCET = low-carbon energy transition – carbon neutral.
Source: Authors' calculations.

Power Generation Investment

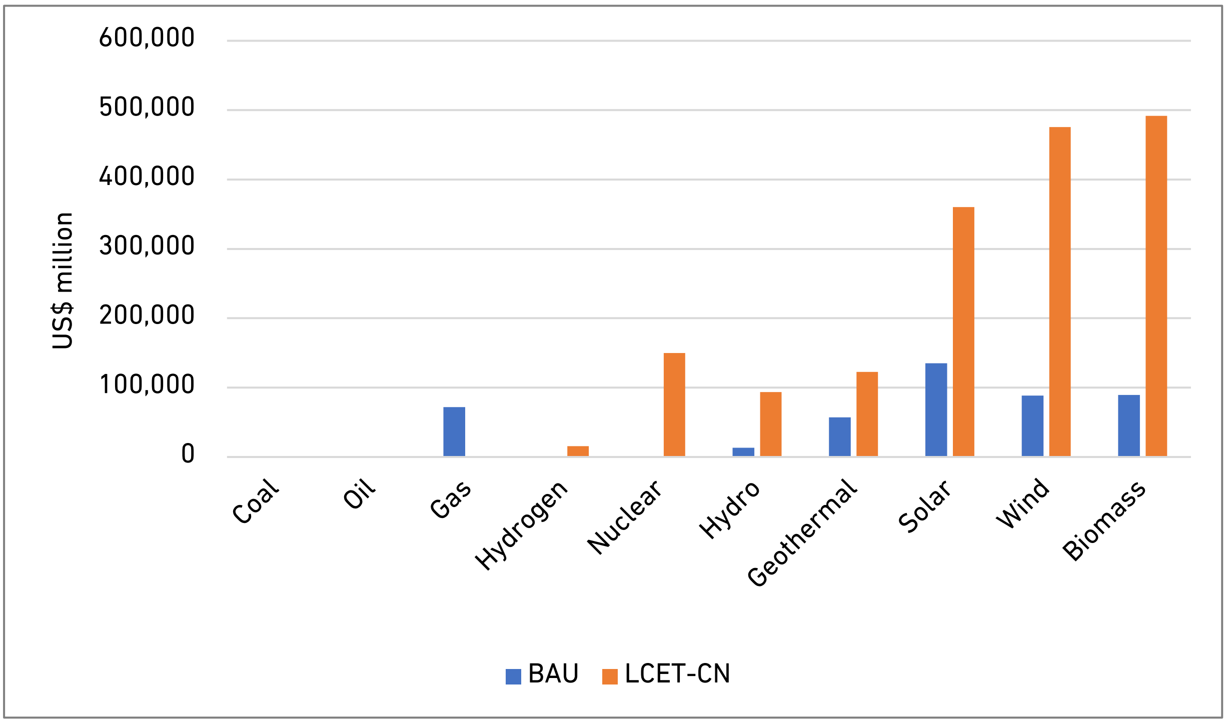
In contrast with the savings observed in fuel costs, US power plant construction costs are significantly higher under the LCET–CN scenario compared to the BAU scenario. Key to this picture is the significant additional power generation capacity requirements of the LCET–CN scenario (1,629,149 MW) vs BAU (662,810 MW). However, scenario variations in the kinds of new capacity coming online – as shown in Figure 17.14 – also contribute to further widening cost differences, given the relatively higher per KW construction costs of wind, nuclear, and biomass projects (which are relatively more prominent under the LCET–CN scenario) versus natural gas projects (which is more prominent under the BAU scenario). The net impact of these trends is that between 2019 and 2050, power plant construction costs are projected to be roughly US$1,709,809 million under the LCET–CN scenario versus US$455,455 million in BAU – or roughly 3.8 times higher under LCET–CN than under BAU (Figure 17.15).

Figure 17.14. Power Plant Capacity Additions under BAU vs. LCET–CN Scenarios



BAU = business as usual, LCET = low-carbon energy transition, MW = megawatt.
Source: Authors' calculations.

Figure 17.15. Power Plant Construction Investment under BAU vs. LCET–CN Scenarios

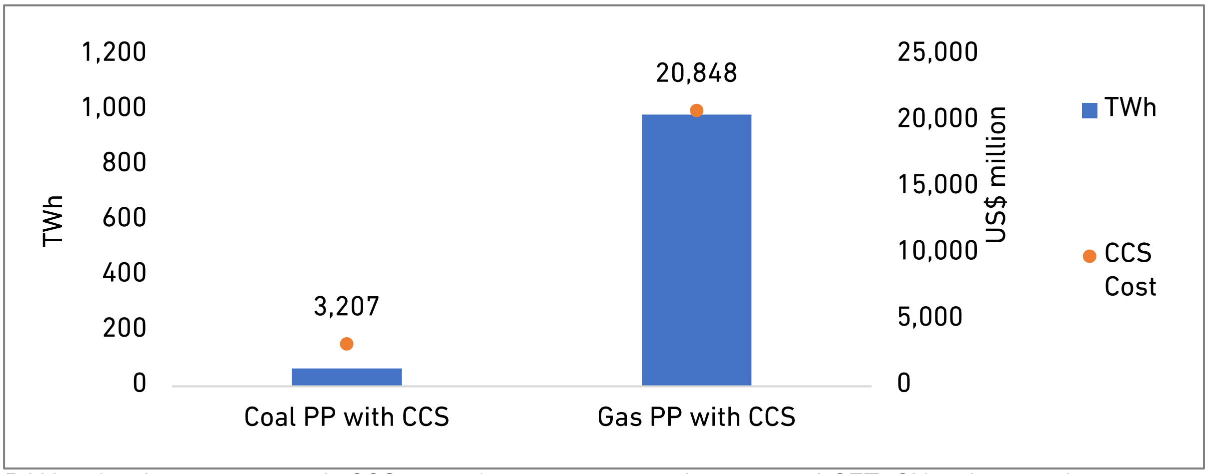


BAU = business as usual, LCET–CN = low-carbon energy transition – carbon neutral.
Source: Authors' calculations.

Carbon Capture and Storage Cost

Spending on CCS is also assumed to be higher under the LCET–CN scenario than BAU; unsurprising given the technology's prominence in the LCET–CN scenario and absence in BAU. As shown in Figure 17.16, the vast majority of these costs are associated with the substantial applications of CCS technologies in gas-fired power plants, with relevant costs in 2050 alone amounting to US$20,848 million. However, spending associated with the country's increasingly modest fleet of coal-fired power plants is also significant, at US$3,207 million in 2050.

Figure 17.16. CCS Costs under BAU vs. LCET–CN Scenarios in 2050



BAU = business as usual, CCS = carbon capture and storage, LCET–CN = low-carbon energy transition–carbon neutral, PP = power plant, TWh = terawatt-hour.
Source: Authors' calculations.

Overall Cost

Table 17.1 summarises the overall differences in costs between the BAU and LCET–CN scenarios in 2050. It suggests that, over time, the LCET–CN scenario's higher costs in terms of power plant construction requirements and spending on CCS are offset by significant savings on fuel costs; such that in 2050, the cost of the LCET–CN scenario is roughly 47.8% of that for BAU. That being said, it should be noted that over the outlook period, the LCET–CN scenario envisions a faster rate of growth in power capacity needs in the first half of the period and a faster rate of decline in fuel requirements during the second half of the outlook period. This is something that could undermine the narrative of LCET–CN's 'economic benefits' in individual years, given when new spending will be required verses when savings will be realised.

Table 17.1. Cost Comparison of BAU vs. LCET–CN Scenario

(US$ millions)

	BAU	LCET–CN
Fuel Costs in 2050	681,701	253,964
Power Plant Construction Costs (Average Annual Cost for 2019–2050)	14,692	55,155
CCS Costs in 2050	0	24,055
Total	696,393	333,174

BAU = business as usual, CCS = carbon capture and storage, LCET–CN = low-carbon energy transition–carbon neutral.
Source: Authors' calculations.

4. Implications

- In both the LCET–CN and AP scenarios, zero-carbon sources are now anticipated to account for most of the US electricity generation mix by 2050, and under the LCET–CN scenario, variable renewable energy sources alone are expected to represent more than 50% of the total mix. Yet to sustain such switching, greater attention to bolstering enabling infrastructure as well as advancing new breakthroughs in storage technologies will be crucial.
- Continued efforts to strengthen the transport sector are envisioning as a critical opportunity for energy saving under all scenarios. In addition to accelerated deployment of electric vehicles, greater attention to fuel efficiency and technologies for overall cleaner consumption will be critical. Hydrogen, too, has a potentially prominent role to play.
- Even amidst the changes above, oil and natural gas are anticipated to represent a sizeable share of the United States' energy mix in both the BAU and AP scenarios and are still relatively prominent under the LCET–CN scenario. To get to 'net-zero' by 2050, finding ways to radically decarbonise the consumption of these fuels is thus an important imperative alongside switching to renewable and other alternative energy sources. In turn, leading on these efforts could also bolster the long-term competitiveness of US fossil fuel exports as a means of how Asia might advance its own energy and environmental security goals.
- Pursuing a 'carbon neutral' energy mix is likely to dramatically reduce US expenditures on fuel – especially, but not only, on oil. However, it will also require substantial new investment in power plant infrastructure and, at least in some individual years in the outlook period, is expected to have higher associated costs

than BAU. Whilst this study finds the LCET–CN scenario ultimately producing strong environmental and economic benefits for the US, clear communication and ongoing engagement with key stakeholders and the public will be essential to sustaining support for what, at times, is expected to be a challenging transformation. Alongside this, continued US–Asia dialogue can also play an important role in helping to support these efforts and share lessons learned.

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