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 1990, its population has grown at an average annual rate of 2.4%, reaching approximately 321 million in 2015.[1] As of 2018, 82.3% of its total population lives in urban areas, with the trend towards increased urbanisation expected to continue at an average annual rate of change of 0.95% throughout the current 2015–2020 period (CIA, 2018).

The US is also the world's second-largest economy, with a gross domestic product (GDP) of $16.9 trillion and per capita income of $51,640 in 2015 (both in constant 2010 US$ values). By sector of origin, 80.2% of its GDP can be linked to services, while 18.9% is linked to industrial output, including motor vehicles, aerospace, chemicals, and consumer goods. Agriculture, including wheat, corn, beef, dairy, and forest products, makes up the remaining 0.9% (CIA, 2018). International trade also plays a crucial role in the overall strength and health of the US economy. As one measure of this, studies have suggested that in numerous areas of the country, more than one-quarter of state-level GDP can be attributed to international trade, including in Washington, Michigan, Louisiana, Texas, and New Jersey (Perry, 2018).

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

1.1. Energy Situation

The US is the world's second-largest consumer of energy and the second-largest emitter of CO_2, though by per capita measures, it ranks first in both categories. In 1990, its final energy consumption was 1,294 million tons of oil equivalent (Mtoe). Over the following decade, consumption increased to 1,546 Mtoe in 2000, and then experienced a modest overall decline in 2000 to 2015 so that consumption was 1,520 Mtoe as of the end of 2015. Different studies have contested whether this indicates that US consumption has peaked, or if a gradual recovery in economic activity following the 2007–2008 global economic crisis may have ultimately reversed this trend. Periodically cited as evidence is that between 1990 and 2015, only industry sector consumption declined overall (though non-energy sector consumption has also declined in the period since 2000). Meanwhile, energy consumption in the 'others' (residential/commercial/public) sector and transport grew steadily.

During this period, coal consumption also declined sharply from 56 Mtoe to 20 Mtoe, but growth in consumption of natural gas and renewables more than offset this decline. A key contributor to this is the major shift under way in the US's domestic energy supply outlook. While the country has long had abundant, diverse resource potential – including substantial natural endowments in fossil fuels such as coal, shale oil, and natural gas; geothermal and hydroelectric potential; and favourable conditions for wind and solar energy – up until recently, significant portions of this potential were not considered technically or economically viable. However, since the 2000s, breakthroughs in technology, declining production costs, and favourable environments for development and investment have contributed to a growing abundance in accessible domestic resource potential. Between 2008 and 2013, the incremental increase alone of US daily oil production was equivalent to the total daily oil production of Iraq in 2010 (Richardson-Barlow et al., 2014). The International Energy Agency estimates that the US will be the world's largest oil producer by 2023. Natural gas production also increased twelvefold during a similar period, resulting in the US becoming a top producer of natural gas (Richardson-Barlow et al., 2014).

As has been well documented, such developments are now having a crucial, transformative impact on reshaping US energy outlooks. Rises in production levels of oil and natural gas are contributing to reducing or backing out of import requirements from Canada and other country sources. Combined with other market and policy factors, energy independence is also contributing to accelerating trends in transforming the US power generation mix. In 2014, for the first time ever, natural gas surpassed coal as the single largest share of US power generation. Meanwhile, increasingly favourable economics, coupled with

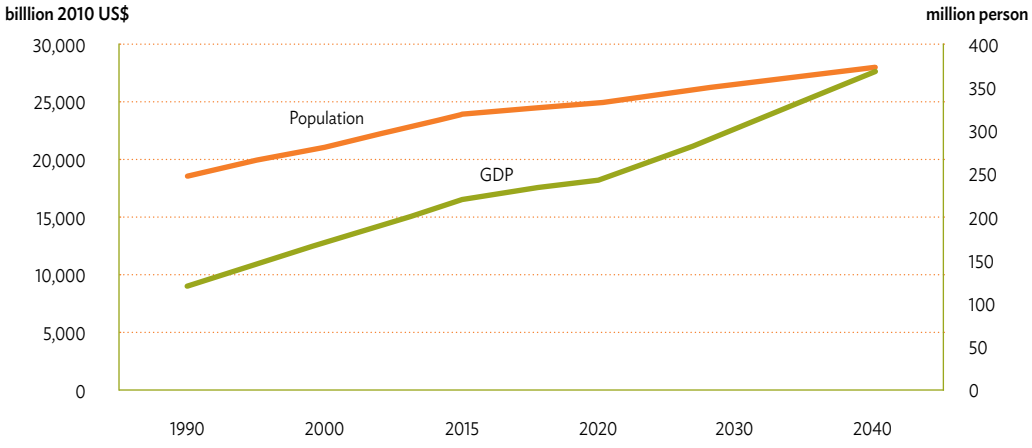
supportive domestic policy environments, also contributed to significant increases in consumption levels for wind and solar, which grew at the largest rates of increase of any fuel source in between 1990 and 2015. In some states of the US, including Texas and Iowa, wind energy is considered cost competitive with traditional fuel sources, which may further incentivise further consumption (Gillespie, Johnson, and Schwartz, 2017).

Expanded production and reduced requirements for domestic consumption (particularly of abundant, high-quality indigenous coal resources) have also opened the door for the US to play an increasingly important role as a key exporter to the Asia-Pacific region. To date, US liquefied natural gas exports have been delivered to several major economies in Asia, including Japan, Taiwan, India, the Republic of Korea, and China, and frequency and volumes are anticipated to grow exponentially in the coming decades (EIA, 2018a). The US is also becoming an increasingly important supplier of crude oil to Asia. It is also an important global exporter of coal, with India, the Republic of Korea, and Japan representing three of the top five recipients of US steam coal exports in 2017 (EIA, 2018b). Going forward, while each of these fuel sources may potentially contribute immensely to strengthening regional energy security outlooks, factors such as overall competitiveness of US supplies, social licence considerations in both the US and Asian countries, and the need to overcome current bottlenecks in US transport infrastructure may limit the overall potential of US export growth.

2. Modelling Assumptions

Over this study's outlook period of 2015–2040, 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 (Figures 18.1 and 18.2). While US birth rates are projected to remain below replacement levels during the outlook window, its population continues to grow overall due to sustained immigration and improvements in life expectancies. However, at 0.6% per year, population growth rate for the outlook period is still at a notably slower pace than the 1% of the previous 25-year period (CIA, 2018).

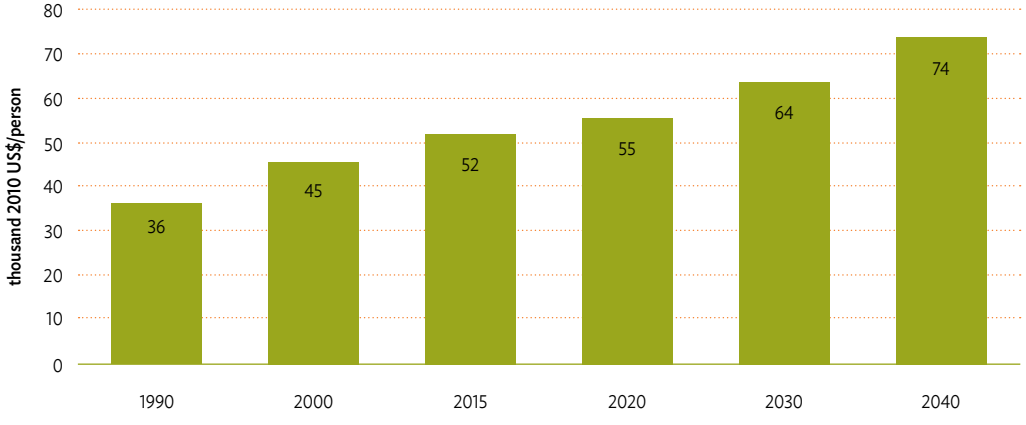
Figure 18.1: GDP and Population (1990–2040)



GDP = gross domestic product.

Source: Authors' assumptions.

Figure 18.2: Per Capita GDP (1990–2040)



GDP = gross domestic product.

Source: Calculation based on authors' assumptions.

Between 1990 and 2015, US GDP grew at an average annual rate of 2.4%. Despite significant disruption in this overarching trend during the 2007–2008 global economic crisis, the US economic outlook appears to have now recovered dramatically by several measures. However, ongoing questions about job creation rates and challenges in increasing productivity remain looming challenges to realising new gains in GDP growth. This model projects that GDP growth rates will re-stabilise over the outlook period at rates comparable, though modestly lower, than the prior 25 years. Between 2015 and 2040, average annual growth will continue at 2.1% per year, and each decade snapshot will relatively closely mirror this overall trend (with the 2030–2040 period being the sole outlier at the slightly slower pace of 2%). This estimate aligns with expectations of continued efficiency and productivity gains alongside the above modest but sustained

population growth, as well as continued US leadership and commitment to innovation in emerging fields.

In terms of overall total final energy consumption (TFEC), oil is anticipated to retain its dominance through the outlook period, reflecting that by sector, transport also remains the single largest driver of the TFEC. In electricity generation, while coal, nuclear energy, and hydropower are each anticipated to remain critical components of the overall US mix, each of these sources is anticipated to decline in terms of their overall share between 2015 and 2040. This is primarily due to unfavourable economics and domestic policy and social licence factors when compared with the outlooks for non-hydro renewables and natural gas. Investments in cleaner consumption technologies as well as the retirement of ageing coal-fired power fleets are also anticipated to boost overall efficiency of generation. However, uncertainties about the pace and scale of retirement of existing nuclear power plants weigh on the overall trajectory for reducing CO_2 emissions.

The Alternative Policy Scenarios (APSs) assume progress towards the full implementation and realisation of a range of established efforts to strengthen a country's energy-saving potential. For the US, these include 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. Calculations are modelled based on a review and assessment of current laws and policies in place at the national and state levels. This study then reviews the results of the APSs to determine cumulative impact in promoting CO_2 emissions reductions and encouraging energy savings beyond business-as-usual.

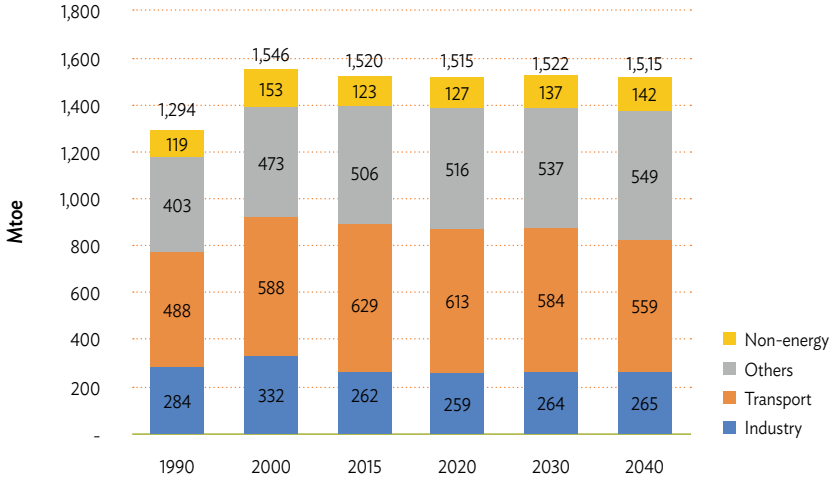
3. Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final energy consumption

Under the Business-As-Usual (BAU) scenario, the TFEC is anticipated to decline slightly between 2015 and 2040, though at 1,515 Mtoe, it remains well above 1990 levels (Figure 18.3). The transport sector is the only sector whose consumption is anticipated to decline, with efficiency improvements and other structural changes within the sector offsetting prospects for additional consumption despite continued growth in vehicle ownership. Meanwhile, consumption by industry, non-energy, and 'others' (residential/commercial) sector grows. The largest growth is experienced in the 'others' sector, though non-energy sector consumption grows at the fastest rate.

Figure 18.3: Final Energy Consumption by Sector, BAU (1990–2040)

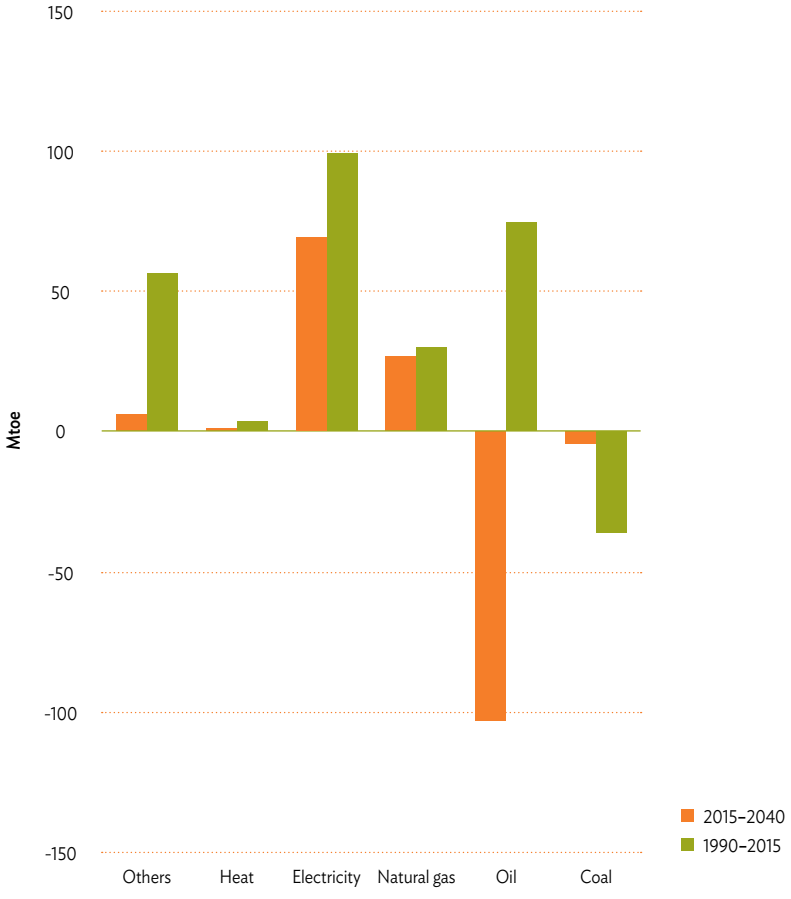


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

During this same period, electricity consumption is anticipated to grow from 325 Mtoe to 376 Mtoe. Non-hydropower renewables, primarily wind and solar but also geothermal, will experience the most dramatic growth during this period. Natural gas consumption remains relatively stable up to 2030 but is anticipated to modestly decline through the end of the outlook period. Coal consumption declines throughout the entire 2015–2040 period, although at a much slower pace than in the previous 25 years. Oil consumption experiences the most dramatic decline, given robust expectations for continued efficiency gains as well as switching in the transport sector to natural gas, biofuels, and other sources as well as increased deployment of electric vehicles (Figure 18.4).

Figure 18.4: Changes in Final Energy Consumption by Fuel Type, BAU



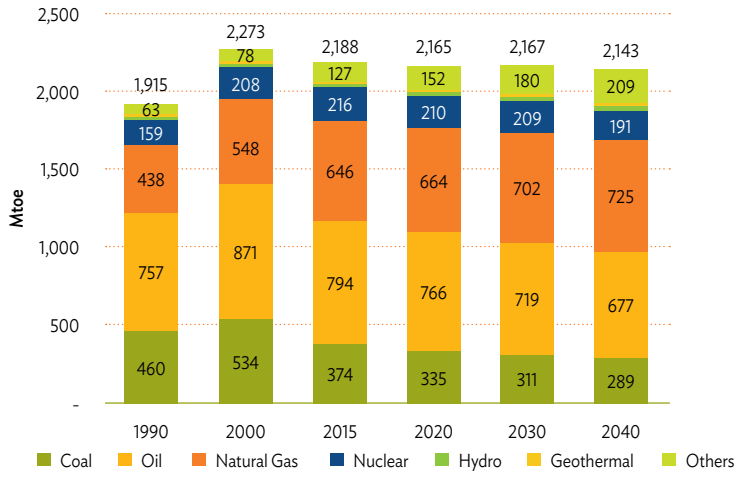
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.1.2. Primary energy consumption

Under the BAU scenario, total primary energy consumption is anticipated to decline from 2,188.3 Mtoe in 2015 to 2,143 Mtoe in 2040, with an average annual rate of decline of 0.1%. Of note, much of this overall decline is also anticipated to already have occurred by 2020. Coal consumption is anticipated to decline at a rate of 1.0% during this period, while nuclear declines by 0.5%. In contrast, non-hydropower renewables experience the largest growth in consumption during this period at 5.3%, closely followed by geothermal at 4.4% (Figure 18.5).

Figure 18.5: Final Energy Consumption by Fuel Type, BAU (1990–2040)

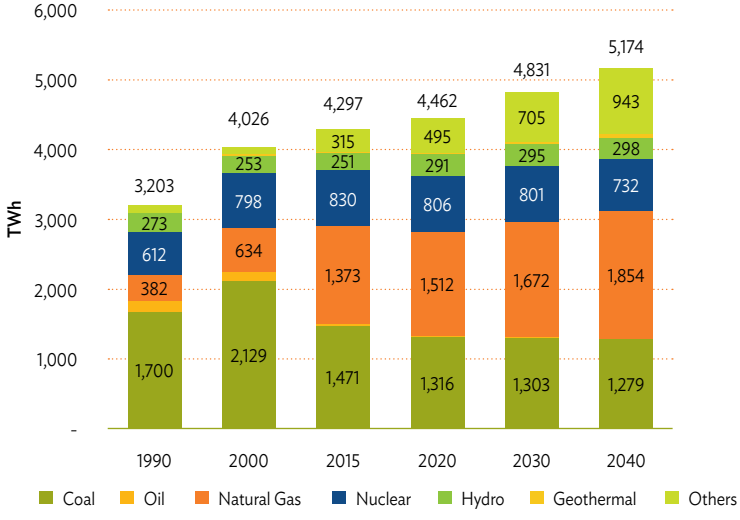


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.1.3. Power generation

Figure 18.6: Power Generation under BAU (1990–2040)



BAU = Business-As-Usual, TWh = terawatt-hour.

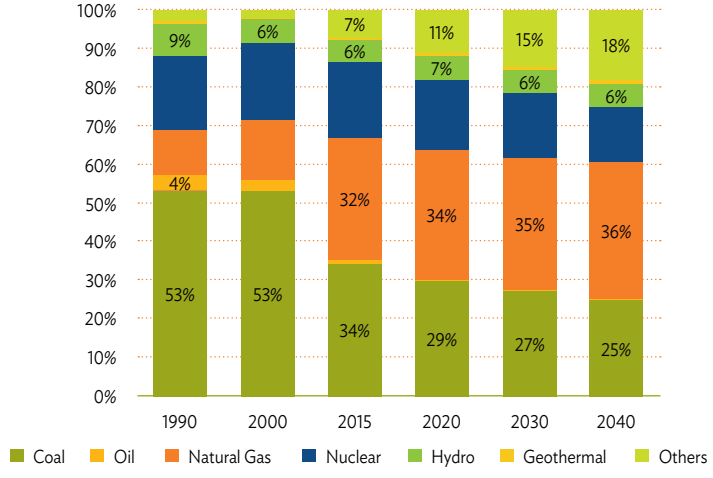
Source: Authors' calculation.

Electricity generation in the US, under the BAU scenario, is projected to increase over the outlook period, though at a comparatively slower pace than in the previous 25 years. Generation output increases from 4,297.0 terawatt hours (TWh) to 5,173.8 TWh between 2015 and 2040, for an average annual growth rate of 0.7%.

After surpassing coal as the single largest share of the US's power generation mix in 2014, natural gas retains its number one rank through 2040, representing 35.8% of the overall mix. The largest average annual growth rates are seen in non-hydro renewables, most prominently solar and wind, as well as potentially geothermal. Improved economics alongside other considerations could also contribute to incentivising higher levels of consumption of wind and solar though, as aptly noted by the Energy Information Administration, many existing tax credits will begin to expire in the early 2020s, potentially raising questions for the road ahead (Figure 18.6).

The retirement of older, less-efficient coal-fired plants and ongoing technological improvements promoting more efficient consumption are assumed to play important roles in shaping this outlook alongside broader market and policy forces that may incentivise switching. Coal continues its decline at 0.6% a year, though it is still anticipated to account for roughly one-quarter of all US power generation in 2040. Uncertainties in investments and progress towards strengthening existing, ageing grid infrastructure may also challenge efforts to bring new generation online in ways that promote energy savings and CO_2 reductions (Figure 18.7).

Figure 18.7: Share of Power Generation Mix under BAU (1990–2040)



BAU = Business-As-Usual.

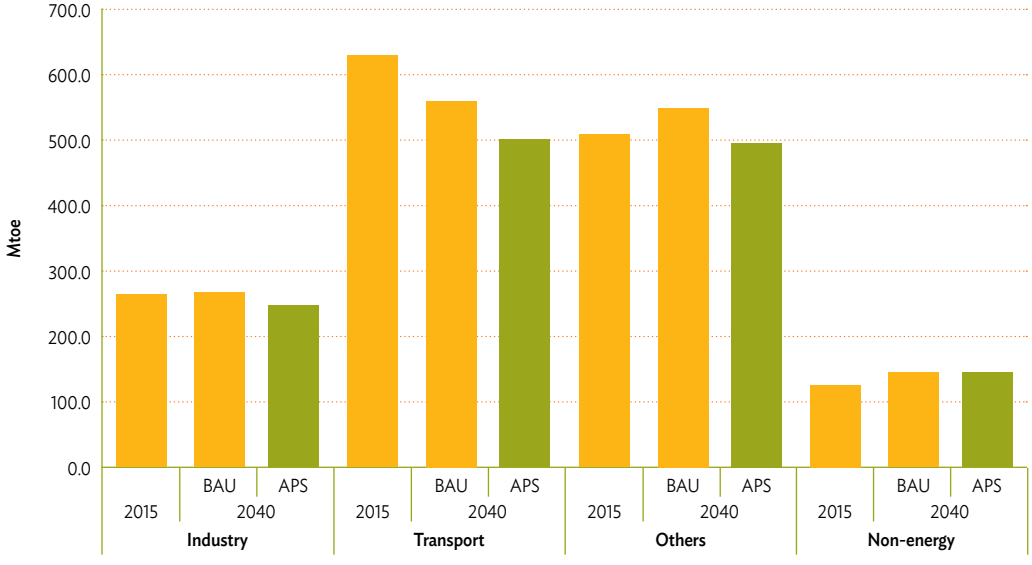
Source: Authors' calculation.

3.2 Energy Savings in the APS and CO_2 Reduction Potential

3.2.1. Final energy consumption

Under the APS, this study projects that early signs of declining TFEC in the US will be affirmed and that the overall rate of decline will also be accelerated. Under the APS, this study anticipates that in 2015–2040, consumption will decline from 1,520 Mtoe to 1,379 Mtoe. When compared with the BAU scenario, this shows an energy savings of 135.8 Mtoe or 9% during the period. Transportation realises a savings of 57.6 Mtoe (10.3%); industry, 21.8 Mtoe (8.2%); and residential and commercial, 56.4 Mtoe (10.3%). Meanwhile, in contrast to expectations under the BAU scenario, all sectors save for non-energy now realise some level of declining overall consumption (Figure 18.8).

Figure 18.8: Final Energy Consumption by Sector in BAU vs. APS

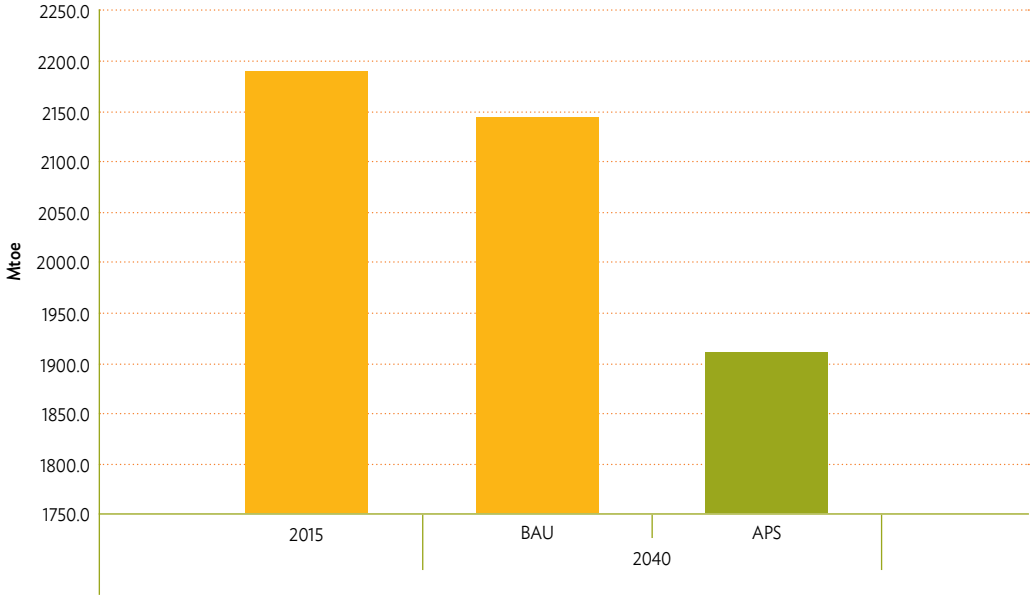


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.2.2. Primary energy supply

Figure 18.9: Total Primary Energy Supply in BAU vs APS (2015 and 2040)



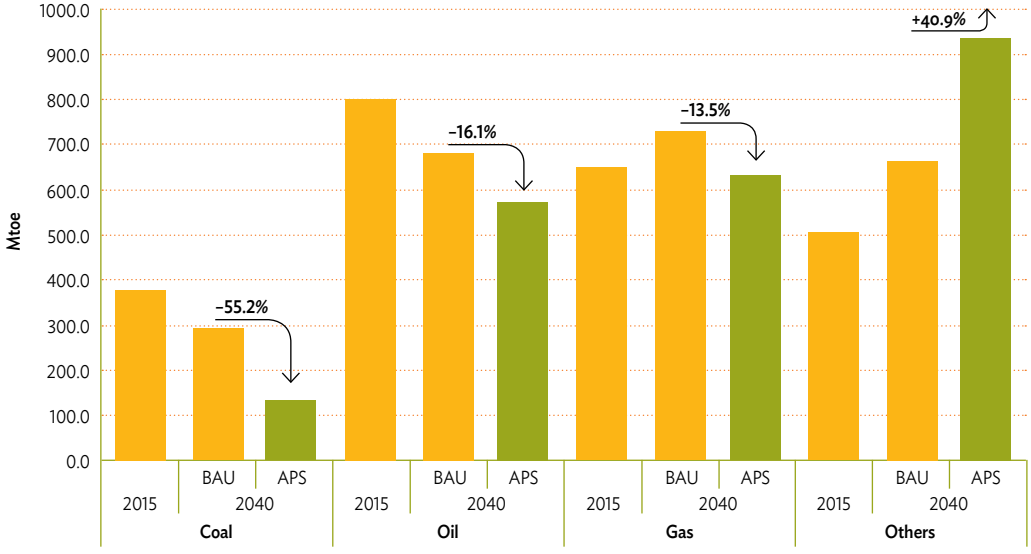
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Under the APS, US primary energy consumption is anticipated to decrease from 2,188.3 Mtoe in 2015 from 1,910.2 Mtoe in 2050. This implies that, in 2040, under the APS, savings of primary energy consumption will be around 232.73 Mtoe or 10.9% lower compared with the BAU scenario (Figure 18.9).

Coal in the primary energy demand in the APS is expected to decline to 129.7 Mtoe. This represents a total energy saving of 159.6 Mtoe in 2040 compared with the BAU scenario. Oil consumption is also anticipated to decline compared to the BAU scenario, with a potential saving of 109.3 Mtoe (or 16.1%) by 2040, while natural gas is also anticipated to see a similar level of decline. In contrast, the demand for others (renewables) is anticipated to increase to about 270.35 Mtoe (40.9%) compared to the BAU scenario in 2040 (Figure 18.10).

Figure 18.10: Total Primary Energy Supply by Fuel in BAU vs APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

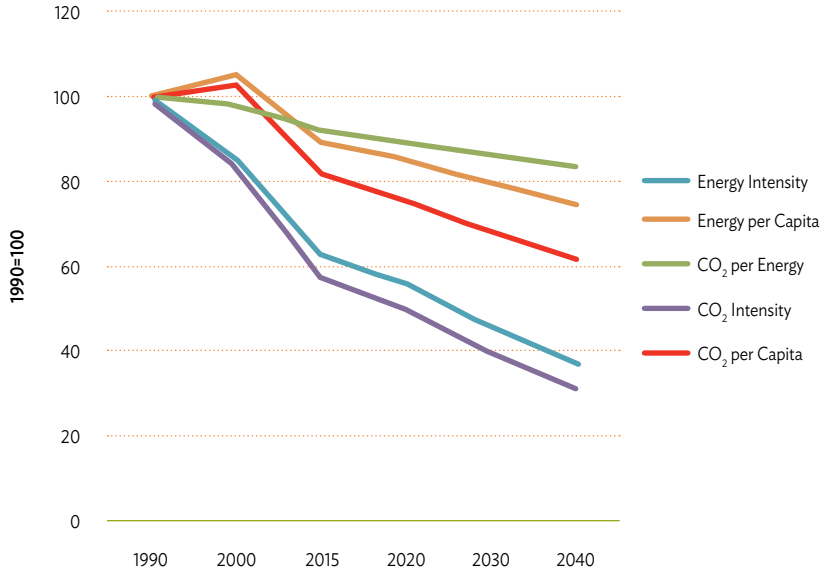
3.3. CO_2 Emissions

CO_2 emissions from energy consumption, under the BAU scenario, are anticipated to decline modestly – from 1,382.9 million tons of carbon (Mt-C) in 2015 to 1,228.9 Mt-C in 2040. This is equivalent to a decrease in average annual rate of 0.5%. Key drivers of this shift is due to continued fuel switching in the electricity mix of the US. Decreased consumption of coal and oil and increased consumption of natural gas and non-fossil sources contribute to modest improvements in the country's overall emissions profile.

In the APS, CO_2 emissions are projected to decrease at an average annual rate of 1.7%, from 1,382.9 Mt-C in 2015 to 902.2 Mt-C in 2040. Emissions savings in the APS are thus 26.6% compared to the BAU scenario in 2040. The most dramatic shifts in primary energy consumption between the BAU scenario and the APS are linked to the acceleration of trends in reducing coal – a difference of 55.2% by 2040 – while oil consumption is reduced by an additional 16.1% and gas by an additional 13.5% (Figure 18.11).

In the official submission of its Intended Nationally Determined Contribution (INDC), the US pledged to reduce CO_2 emissions from their 2005 levels by 26%–28% by 2025. While the current US (Trump) administration has raised the prospects of revising or abandoning its current INDC pledge, this study suggests that the US has already made substantial progress towards this goal. However, even under the APS, more robust actions may be necessary to achieve this target by 2025.

Figure 18.11: CO_2 Emissions Trends under APS (1990–2040)



Source: Authors' calculation.

4. Policy Implications

Based on the results and discussions presented above, the following policy implications could be derived:

- Coal, oil, and natural gas will continue to dominate the US energy mix in both the BAU scenario and the APS.
- Natural gas will remain as the single greatest share of the US electricity generation mix in 2015–2040, although non-hydro renewables such as wind and solar are anticipated to experience the largest growth rates.
- Improved economics alongside sustained breakthroughs in renewable energy technologies could also contribute to incentivising higher levels of consumption in ways that further accelerate CO_2 emissions and promote energy savings. However, as the Energy Information Administration notes, substantial uncertainties lie ahead, including determining the implications and desirable responses to expiring tax credits and fiscal incentives for renewable energy in the 2020s.
- Continued efforts to strengthen the transport sector are being envisioned as a critical opportunity to save energy under both the BAU scenario and the APS. In addition to accelerated deployment of electric vehicles, greater attention to fuel efficiency and technologies for overall cleaner consumption will be critical, given expectations of a continued prominent role for oil.

- Growing potential for US energy exports to Asia could contribute immensely to strengthening regional energy security outlooks. However, factors such as overall competitiveness, social licence considerations on both sides of the Pacific, and the need to overcome current bottlenecks in US transport infrastructure may limit overall US export growth potential.

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