UNITED STATES

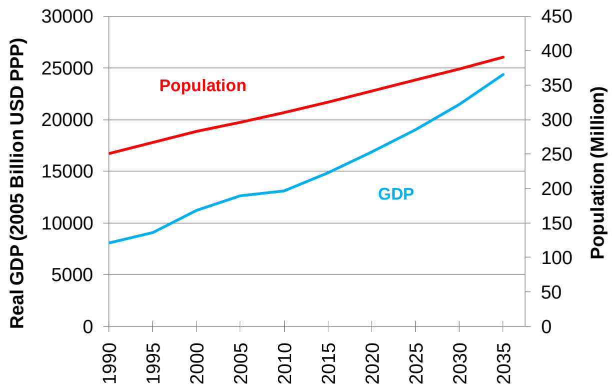
- *Economic recovery and population growth combined with aggressive energy efficiency policies will see the US energy demand grow slowly over the 2010–2035 outlook period.*
- *The US has uncovered vast shale oil and gas reserves which will see domestic production dramatically reverse its long standing decline and accelerate US energy security and economic growth.*
- *Coal use will decline quickly in the electricity sector. Total annual CO_2 emissions from fuel combustion will decline to around 5050 million tonnes in 2035 or 13% lower than in 2005. However, emissions per capita will still be higher than most other wealthy economies and above the level required worldwide to avoid damaging climate change.*

ECONOMY

The United States (US) is the world's largest economy. In land area, it is geographically diverse and resource rich.

The US population was about 310 million in 2010 and continues to increase steadily as a result of positive immigration, a stable replacement birth rate (about 2.05 births per woman) and a positive ratio of births to deaths (CIA, 2011). The population is expected to grow to around 391 million over the outlook period. About 82% of the population is urban—this is projected to increase in share to 88% by 2035 (UN, 2011).

Figure US1: GDP and Population



Sources: Global Insight (2012) and APERC Analysis (2012)

Economic growth in real GDP will be moderate, with a growth rate averaging 2.5% per year between 2010 and 2035. By 2035, total GDP is expected to reach USD 24.3 trillion in real 2005 dollars

The average per capita income in real 2005 dollars was USD 42 200 in 2010, which using purchasing power parity (PPP) per capita places the US comfortably in the top 10 wealthy economies in the world (IMF, 2011). However, the distribution of wealth in the US is among the most unequal for a mature and developed economy (CIA, 2011). The percentage of people below the defined poverty line was approximately 15% in 2010, the highest level since 1993 (US Census Bureau, 2011b).

Owing to its geographical size the US has a diverse climate and landscape. The vast majority of the US has a moderate climate which supports its large tracts of arable and fertile land. However, the southwestern states tend to be very dry, and their agriculture depends on artificial irrigation. Almost all areas typically experience heat waves during summer; the northern regions experience severe cold and snow storms during winter. Summer cooling and winter heating of buildings are almost universal. The western US states are geologically prone to earthquakes; the states in the mid-west and in the Gulf of Mexico are also prone to severe weather events such as tornados and hurricanes.

The US enjoys one the highest standards of living in the world. The economy relies on domestic consumption, which accounted for 70% of total GDP during the decade up to 2010 (Hubbard and Navarro, 2010). The US economy is highly service based, and supported by a productive and educated workforce. The US has a net trade deficit which equated to about 3.4% of GDP in 2010 (US Census Bureau, 2011c). Other key sectors include agriculture, manufacturing and mining.

The industry sector is one of the major energy consumers in the US economy. This sector is made up of energy intensive industries, such as those that produce aluminium, chemicals, paper and steel. The US has a growing high-tech industry which is less energy intensive than the older 'smokestack' industries. A shift toward less energy intensive industries has also been driven by growing global competition for low-tech industrial production. This has led to the gradual shift to a service based economy.

US cities were developed during the advent of cheap energy and an ample supply of land. Consequently, US cities have high levels of urban sprawl which has led to high per capita vehicle ownership. The US also has the world's largest interconnected highway system and a comprehensive network of urban and intercity motorways. The combination of high vehicle ownership, an extensive highway network and low attention to energy efficiency has led to especially high transport energy use per capita. The economy's dependence on automobile mobility is unlikely to change by 2035.

Automobiles and air transport are the dominate means of intercity passenger travel. US public transport is typically of fair to poor quality relative to other industrialized economies, and its market share is relatively small outside of a few cities with compact central business districts (such as New York). The public transport system is heavily subsidized with ticket revenue comprising only about 38% of operational costs in 2010. However, since 1995, public transport has seen sustained growth with total transit trips increasing over 30% between 1995 and 2010. This growth was more than twice the rate of population growth over the same time (APTA, 2012).

The US has a diverse freight transport industry which includes many kinds of highway carriers, ocean and inland waterway shipping, and domestic and international air freight. Most interesting, from an energy perspective, is the US rail freight system. It is largely unsubsidized and considered to be one of the world's most productive and efficient rail freight systems (The Economist, 2010). In terms of ton-miles, rail freight accounted for about 37% of total freight volumes in 2009 (RITA | BTS, 2012).

The US has a particular endearment for sport utility vehicles and pick-up trucks which represented a 43% share of the total light vehicle fleet in 2011 (USDOE, 2012). The rapid rise in oil prices since the early 2000s combined with the onset of the financial crisis in 2008 has caused a severe downturn for US automobile companies. From 1998 to 2010, the light vehicle market share of the three major US automobile companies, General Motors, Ford and Chrysler has declined from 70% to less than 50% (Motor Intelligence, 2011). The US does not import used automobiles, but exports used vehicles, largely to its southern neighbour, Mexico.

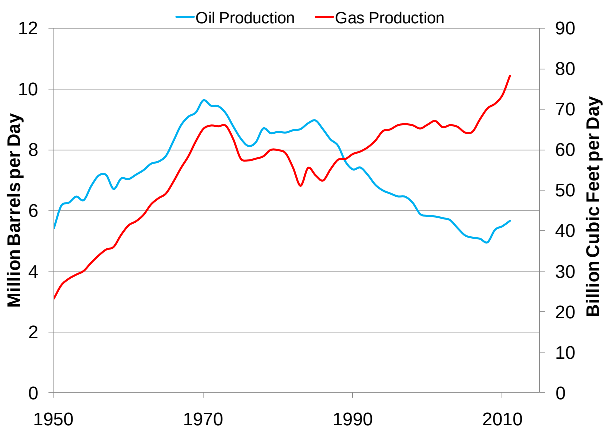
ENERGY RESOURCES AND INFRASTRUCTURE

The US energy scene has changed remarkably. The economy historically ranked as APEC's second largest oil and gas producer (after Russia). However, until recently, it was widely viewed as being on a long-term path to growing oil and gas import dependency as a result of declining oil production and stagnant gas production. This outlook has changed dramatically as a result of the exploitation of new technology for producing unconventional gas and oil, most notably 'shale gas' and 'shale bearing oil'. These technologies are discussed in Volume 1. The US has been the world leader in the development and exploitation of these technologies and their impact on the US oil and gas supply outlook has been significant.

The new technologies have resulted in an increasing production of natural gas and a precipitous drop in gas prices since 2008. The economy is believed to have huge unconventional gas resources with recoverable reserves from shale basins across the US estimated at 482 trillion cubic feet (13.6 trillion cubic metres) (EIA, 2012a). It is likely the US, historically a modest gas importer, will become a modest gas exporter in the 2010–2035 outlook period. The access to plentiful gas supplies and at relatively low prices will unlock further demand in transport, for new electricity generation and directly in industry applications.

Oil production has similarly reversed its decline, aided by rising world oil prices. In addition to shale bearing oil, the US is likely to have significant resources of deep water offshore oil, which can also be exploited using new technology. Although this technology suffered a setback with the Deepwater Horizon oil spill in the Gulf of Mexico in 2010 (see 'Energy Policies' below), the long-term prospects remain solid. The US is a net oil importer—the economy imported a peak of 60% of its demand in 2006 but this dropped steadily to less than 50% of its demand in 2010.

Figure US2: Domestic Oil and Natural Gas Production



Source: Adapted from EIA, 2012b and 2012c

The US is the world's second largest coal producer (after China). US coal reserves are immense, equating to more than one-quarter of the global coal reserves in 2010 and over 200 years of supply at current rates of production (BP, 2011).

Although fossil fuels still dominate the US primary energy mix, new and renewable energy (NRE) resources are growing fast. US biofuel is supplied almost exclusively by corn-ethanol distillers, but cellulosic feedstocks are a promising technology for the future. The economy's capacity to sustainably supply biomass feedstocks for energy use is estimated to exceed 1 billion tonnes per year, which might displace 30% of its current petroleum consumption (USDOE, 2011). Since 2000, following the push to reduce US foreign oil dependency, US biofuel production has risen almost 10-fold to 13.3 billion US gallons (320 million barrels) in 2010 (EIA, 2011). The sustained growth in biofuel production was supported by generous federal subsidies. Currently, in the face of high oil prices and rising budget deficits the federal government is debating whether to continue biofuel subsidies at current levels. The future growth in biofuel production is likely to slow as a result of supply constraints on corn feedstock and of the high cost of using more abundant cellulosic feedstocks.

Wind and solar energy, like biofuels, have a large development potential and have experienced rapid growth in recent years. In 2010 alone, the total wind energy capacity installed was 5116 MW, and from 2007 to 2010 wind installations accounted for over 35% of all new US electricity generating capacity (AWEA, 2010). Solar photovoltaic and thermal systems are also growing rapidly. In 2010, solar installations by capacity reached 956 MW or almost double that in 2009. However, subsidies and state regulations are key mechanisms that have supported NRE and its future growth is dependent on this support continuing in the short term.

The US geothermal capacity is less than 4 GW, with planned capacity additions totalling a further 5 GW (NREL, 2011). Geothermal energy provides largely baseload power using the energy potential of high temperature fluids, located in shallow and extractable geological formations underground. The limited number of drilling locations with high temperature underground resources at shallow depths has restricted new generation capacity. The future of geothermal will largely be limited outside of the planned capacity additions. However there is a lot of potential in the commercialization of technology for deep enhanced geothermal extraction, where the US has vast untapped resources.

The US has the world's largest nuclear generating capacity with 104 nuclear plants, providing nearly 20% of the economy's electricity generation. The last new reactor to join the fleet was brought online in 1996. The high initial cost of nuclear plants, regulatory uncertainties, low demand growth, safety concerns, and the unresolved issue of waste disposal are the major obstacles to adding new reactors. Several new nuclear reactors (largely within existing nuclear facilities) are awaiting the approval of the NRC (*Nuclear Regulatory Commission)* with four recently approved for construction. The US federal government provides generous financial incentives including tax credits, loan guarantees, insurance protection, waste disposal and funding support for advanced reactor technology (WNA, 2012). Growth in nuclear energy is likely to be slow, with competition from low-cost natural gas posing a major threat.

ENERGY POLICIES

The US has a provisional target to reduce total GHG (greenhouse gas) emissions by about 17% below a 2005 baseline, by 2020 (USDOE, 2009). The US did not ratify the Kyoto Protocol, but many states have adopted legislation intended to limit GHG emissions. Twenty-two states, collectively home to nearly half the US population, have adopted GHG emission reduction targets, although the stringency of these varies considerably (Pew Centre, 2012). It is unlikely the US will agree to binding targets or will adopt a carbon tax in the immediate future, due to strong opposition to such measures.

Many states have adopted policies to increase the share of renewable energy in the electricity generation mix. Twenty-eight states have adopted a mandatory renewable portfolio standard (RPS). Such policies require a certain share of retail electricity sales to be provided by renewable generation by a specified year. The share and the year vary state by state, as do other provisions, such as the eligible technologies and the trading of renewable energy credits. For example, the Pennsylvania RPS requires 8% 'Tier 1' renewables by 2020 and defines methane from coalmines as an eligible resource, while the California RPS targets a 33% share of renewables by 2020 and has a more common definition of renewable energy (NCSU, 2007). In California the RPS is proving effective at stimulating NRE development. Since 2003, 2871 MW of eligible NRE capacity has been installed under the RPS mandate, and several compliance targets on the path to the 2020 target have been met. A further 2500 MW of NRE is expected to be commissioned by the end of 2012 (CPUC, 2012).

There are three policies likely to have a substantial impact on both US energy consumption and emissions. These are the new emission standards on pollutants and toxins issued by the Environmental Protection Agency (EPA), the revised corporate average fuel economy (CAFE) standards and the

EPA's proposal to introduce a restriction on carbon emissions in the power sector.

Firstly, the new EPA emission standards on mercury and toxic pollutants will be incrementally applied from 2012. The strict emission standards will be fully enforced by 2015. This will have a major impact on reducing toxic emissions from coal, primarily in the electricity sector (EPA, 2012b). The new standards will require expensive technological retrofits to existing facilities, and will affect almost half the coal generating capacity. Most of the affected coal facilities are over 40 years old and the new standards are likely to result in extensive capacity retirements which may exceed 50 GW.

Secondly, the revised CAFE standards are expected to be finalised in mid-2012. These require new passenger cars and trucks to meet higher fuel economy standards in the years ahead. Specifically, new passenger vehicles and light trucks are required to achieve an annualized fuel economy improvement of 5% and 3.5% per year, respectively, until 2025. For passenger vehicles, the new standard aims to increase the average new vehicle fuel economy from 27.5 miles per gallon in 2010 to 54.5 miles per gallon (23.2 kilometres per litre) by 2025, and to the 'maximum feasible standard' after that (NHTSA, 2011). The new standards have several loopholes which may inhibit their effectiveness. The chief concern is the use of a size weighted average fuel economy, where larger vehicles have lower fuel efficiency targets. This policy was included to eliminate penalties which favour the sales of small vehicles over large vehicles. However, sales of larger vehicles may increase in market share and reduce real fuel efficiency improvements. A published study suggests average vehicle sizes, particularly for light trucks, may increase between 2% and 32% under the new standards. This would result in a net reduction in the average fuel economy of between 1 and 4 miles per gallon (between 0.4 and 1.7 kilometres per litre) (Whitefoot and Skerlos, 2011). Other uncertainties which may reduce the standards' effectiveness include low fees for non-compliance, overstated fuel economy ratings and low targets for heavy trucks. These negative effects are expected to be limited and real efficiency improvements are likely to accelerate under these rules, but perhaps at a less than anticipated rate.

Finally, the EPA is proposing to limit CO_2 emissions in the power sector. The proposed standard restricts CO_2 emissions to a limit of 454 kilograms (1000 lb) for every megawatt-hour of electricity produced. These proposed restrictions only apply to new generating units and exclude existing units in operation or under construction. The regulation is aimed at limiting climate change by enforcing the use of modern and more efficient fossil fuel generation technologies (EPA, 2012a). The carbon restriction will essentially require new coal plants to operate using the latest high efficiency technology or to employ carbon sequestration. However, at the time of writing, the proposed standards are still under appeal thus adding uncertainty to whether the restrictions will become law.

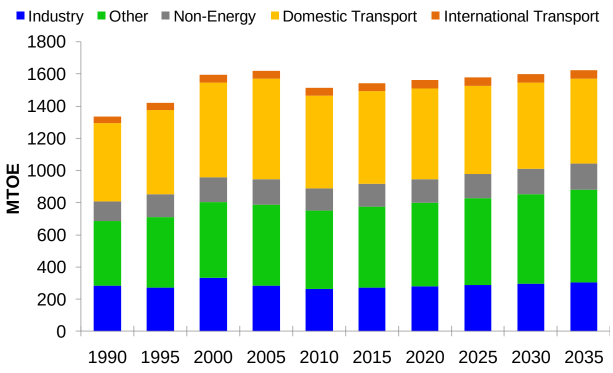
Oil exploration suffered a major setback in the wake of the deep water BP oil spill in the Gulf of Mexico in July 2010. A moratorium on new deep water exploration was initially enforced, but lifted in October 2010 with improved safety regulations on future deep water drilling operations. The US has an extensive, efficient, diverse and long standing oil and gas exploration industry. The oil and gas industry is entirely privately owned and foreign investment is generally welcomed. Tax breaks for major exploration companies are under political scrutiny: however, the industry is supported by robust growth in unconventional oil and gas exploration.

BUSINESS-AS-USUAL OUTLOOK

FINAL ENERGY DEMAND

Business-as-usual (BAU) final energy demand is expected to grow at only 0.3% per year over the outlook period. The largest component of demand growth will be from the 'other' sector (residential, commercial, and agriculture). Growth in transport will remain flat.

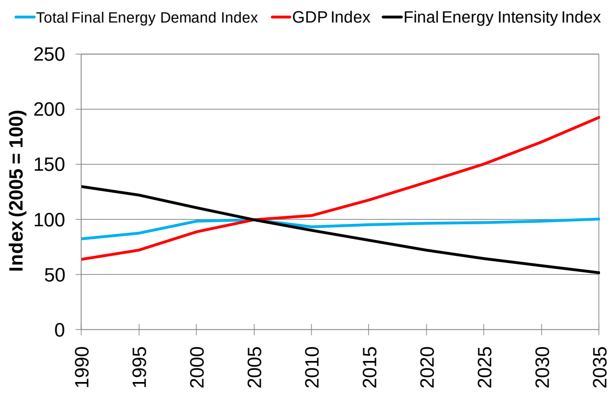
Figure US3: BAU Final Energy Demand



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Final energy intensity is expected to decline by about 42% between 2005 and 2035.

Figure US4: BAU Final Energy Intensity



Source: APERC Analysis (2012)

Industry

Energy demand in the industry sector is projected to grow at an average annual rate of 0.6% until 2035. Productivity per worker will continue to rise in manufacturing due to increasing global competition from developing economies. The same competition is also driving improvements in energy efficiency. As the US shifts towards an increasingly service based economy, manufacturing growth will be flat with light industry growth robust. Growth in energy intensive raw product industries such as aluminium, paper, chemicals, cement and steel will be robust with the supply of cheap energy from shale gas. Energy consumption in the industry sector will increase from about 260 Mtoe in 2010 to 300 Mtoe by 2035.

Transport

Over the outlook period, transport energy demand is projected to decline slightly, with an annual decline rate of 0.3%. Energy demand in the international aviation and shipping sector will rise modestly, but the reduction in the domestic transport sector will be more substantial.

For domestic transport, vehicle ownership in the US has reached saturation level. The US automobile fleet will continue to increase slowly in line with population growth, but improved vehicle fuel efficiency combined with consumer response to increasing oil prices will offset the effect of a growing population. Additionally, alternative vehicles will have a modest entry into the market by 2035, with more funding going into R&D and with the support of tax credits and subsidies. With rising oil prices the share of more efficient conventional vehicles such as diesel and CNG (compressed natural gas) vehicles will also modestly increase. Conventional hybrid vehicles (gasoline and diesel) will make up about 13% of the fleet by 2035, with plug-in hybrids accounting for around 10% and hydrogen fuel cell and fully electric vehicles less than 3%.

Other

Energy demand in the 'other' sector, which includes residential, commercial and agricultural demand, is expected to grow the most of all sectors at 0.7% per year over the outlook period. Electricity is expected to remain the main fuel source in this sector, accounting for about 50% of its energy consumption throughout the outlook period.

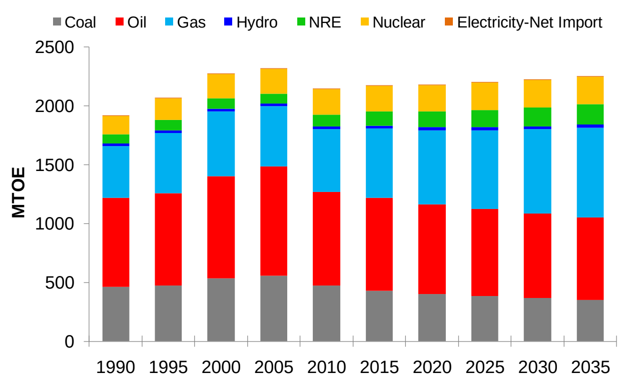
The US median residential floor area increased 36% on average between 1980 and 2010 (US Census Bureau, 2011a). Following the financial crisis in 2008, house sizes have stabilized. With rising urbanization and rising energy prices, floor spaces are expected to remain stable in the outlook period with the demand for small inner city homes outpacing the demand for outer city homes.

The US has a regulatory framework to provide rebates, incentives and R&D in energy efficiency measures. Energy efficiency is a key innovation tool for economic growth. The slight growth in 'other' sector energy demand will be driven by a robust growth in agriculture and by the growth in population. This will offset any energy efficiency improvements.

PRIMARY ENERGY SUPPLY

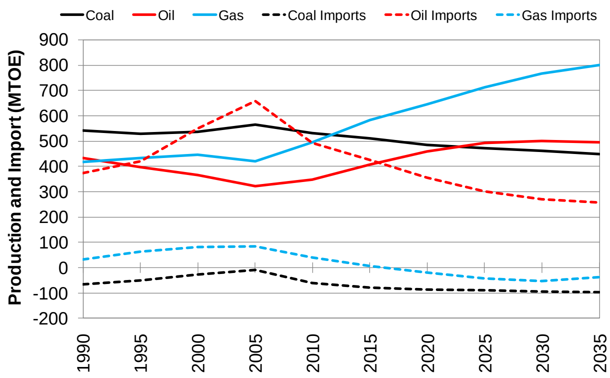
The US primary energy supply in the 2010–2035 period is projected to grow at an annual rate of about 0.2%. The economy will undergo a structural change in primary energy supply fuels, with the share of low carbon fuels increasing rapidly.

Figure US5: BAU Primary Energy Supply



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Figure US6: BAU Energy Production and Net Imports



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

The Obama administration announced a target to reduce US foreign oil imports by one-third by 2025 (Reuters, 2011). In fact, US oil imports are likely to decline over the outlook period to 2035. Under a BAU scenario, a 33% reduction in oil imports from 2010 levels is likely to be achieved at or before the target of 2025. Additionally, the US has aggressively increased its production of biofuel as a direct substitute for oil. The future growth of biofuel is largely dependent on cellulosic feedstock (2nd generation) technology. Cellulosic biofuel is still in the infancy stages—high costs and the need for further advances in technology inhibit its commercialization. Therefore the growth of biofuels is likely to be slow in the medium term until the technology and economics are firmly established.

The acute shortage of domestic natural gas from as early as 1990 led to growing LNG (liquefied natural gas) imports. This equation has changed with unconventional gas production and, assuming government approval, the US is likely to become a modest LNG exporter perhaps as soon as 2017. This is based on an assumption the federal government will not unduly withhold granted export exemptions. At the same time, reduced coal use in electricity generation combined with a strong global coal demand will increase US coal exports. Net domestic coal production will gradually decline.

The medium term outlook for reducing the economy's import dependency is relatively certain, but the long term outlook is not. Unconventional oil and gas technologies are still developing and therefore the ultimate potential of these resources is uncertain. Since the start of commercial shale gas production, technically recoverable shale gas reserve estimates have steadily increased, but recent estimates for 2012 have reduced shale gas reserve estimates 42% from those made in 2011. Technically recoverable shale gas estimates for 2012 stand at 482 trillion cubic feet (or 13.6 trillion cubic metres) but these estimates are uncertain (EIA, 2012a). A further reduction in both the developable unconventional oil and gas resources may see energy dependency reverse its trend in the long term outlook.

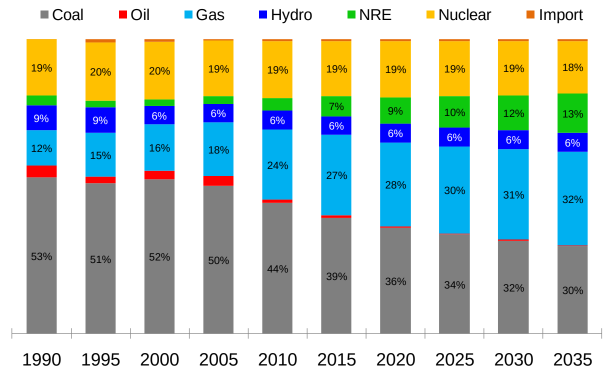
ELECTRICITY

The US electricity sector will also undergo significant changes in the outlook period. In 2011, the EPA (Environmental Protection Agency) issued strict new emission standards for mercury and toxic pollutants (EPA, 2011). The new standards require half of the existing coal generation facilities to either undergo expensive retrofits or to shut down to comply. At the same time, the proposed limits on CO_2 emissions in the power sector add much uncertainty to the economics and regulatory environment of new coal generation. Accompanying the raft of regulatory restrictions, low natural gas prices and subdued electricity demand are putting more pressure on the economics of coal generation. The reduction of capacity by retirements and the diminishing use of coal will result in coal's share of electricity generation dropping from 45% in 2010 to 30% by 2035.

Low cost shale gas and supply security will underpin the growth of high efficiency CCGT (combined-cycle gas turbine) capacity. The share of natural gas generation will increase from 24% in 2010 to 32% by 2035. Additionally, the contribution of NRE will increase over three-fold from about 4% to 13%. Growth in NRE will be led by wind and solar generation, due to reducing installation costs, the attractiveness of the resources and continuing regulatory state and federal incentives. The vast majority of the nuclear energy generating facilities are assumed to extend their operating life to 60 years. Slow capacity growth occurs by up-rating investments in existing reactor facilities. New nuclear reactor additions are unlikely as a result of weak demand growth and low-cost natural gas undermining the capital intensive economics of new nuclear facilities.

The long term stability of natural gas prices and the eventual size of proved shale gas reserve estimates are uncertain. Higher natural gas prices could limit natural gas generation uptake. This in turn is likely to reduce the retirements in coal generation facilities and to improve the growth in NRE and nuclear generation. Additionally, the introduction of a carbon cap, trade or tax is a highly uncertain policy measure with major implications. A moderate carbon pricing policy will significantly improve the growth of NRE and nuclear generation, chiefly at the expense of coal growth and modestly at the expense of natural gas growth.

Figure US7: BAU Electricity Generation Mix

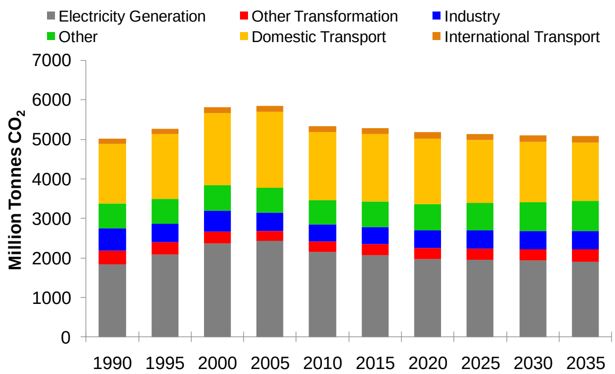


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

CO_2 EMISSIONS

Total CO_2 emissions from fuel combustion reached a peak of about 5850 million tonnes in 2005. It is projected total CO_2 emissions will steadily decrease to around 5100 million tonnes or some 13% lower than the historical peak. Electricity generation emissions will lead the decline with reducing coal generation and growing contributions from natural gas and NRE. However, increasing energy demand from both the industry and 'other' sectors will limit the rate at which emissions reduce. Transport sector emissions will remain the same due to the stable use of oil.

Figure US8: BAU CO_2 Emissions by Sector



Source: APERC Analysis (2012)

The decomposition analysis shown in Table US1 below suggests the growth in GDP will be more than offset by both a reduction in the CO_2 intensity of energy (fuel switching) and a reduction in the energy intensity of GDP (energy efficiency).

Table US1: Analysis of Reasons for Change in BAU CO_2 Emissions from Fuel Combustion

	1990-2005	2005-2010	2005-2030	2005-2035	2010-2035
Change in CO_2 Intensity of Energy	-0.3%	-0.4%	-0.4%	-0.4%	-0.4%
Change in Energy Intensity of GDP	-1.7%	-2.2%	-2.2%	-2.2%	-2.3%
Change in GDP	3.1%	0.7%	2.2%	2.2%	2.5%
Total Change	1.0%	-1.8%	-0.6%	-0.5%	-0.2%

Source: APERC Analysis (2012)

CHALLENGES AND IMPLICATIONS OF BAU

Under business-as-usual, the US energy outlook is reasonably positive. Energy security and per capita GDP will increase, while CO_2 emissions will stabilize at a level 13% lower than in 2005. US per capita CO_2 emissions from fossil fuels remain stubbornly high at about 17.2 metric tonnes per capita in 2010. By 2035, per capita CO_2 emissions from fossil fuels are expected to decline to about 13.0 metric tonnes per capita. However, the US still has significant room to reduce emissions which far exceed the global average needed to prevent damaging climate change. Owing to its status as the world's largest economy and the world's third largest by population, the US is a vital player in any global emissions reduction agreement. The introduction of a carbon tax will have a substantial impact on US CO_2 emissions. In particular, electricity generation is likely to respond to carbon pricing by reducing coal use.

ALTERNATIVE SCENARIOS

To address the energy security, economic development, and environmental sustainability challenges posed by the business-as-usual (BAU) outcomes, three sets of alternative scenarios were developed for most APEC economies.

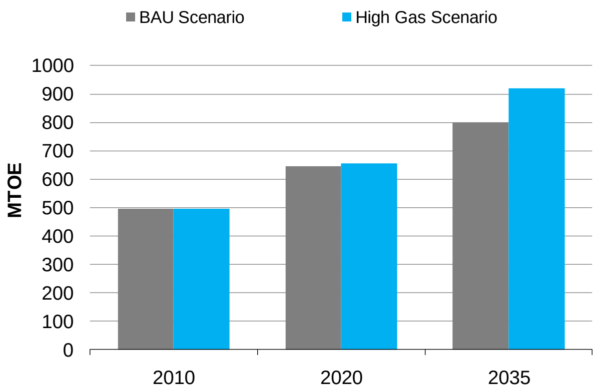
HIGH GAS SCENARIO

To understand the impacts higher gas production might have on the energy sector, an alternative 'High Gas Scenario' was developed. The assumptions behind this scenario are discussed in more detail in Volume 1, Chapter 12. The scenario was built around estimates of gas production that might be available at BAU prices or below, if constraints on gas production and trade could be reduced.

The High Gas Scenario production for the US assumed the production increase shown in Figure US9, which equals 15% by 2035. The US has vast reserves of shale gas which require significant investment in both production and transport infrastructure. The High Gas Scenario assumption primarily removes the restrictions on exports to non free trade economies (which currently require government approval). In turn, this enables greater investment into shale gas production for LNG exports from both the Gulf of Mexico and the West

Coast basins to international markets. The High Gas Scenario also assumed the vast conventional North Slope gas reserves in Alaska are incrementally developed with the project economics supported by improved access to key Asian markets such as Japan and China.

Figure US9: High Gas Scenario – Gas Production

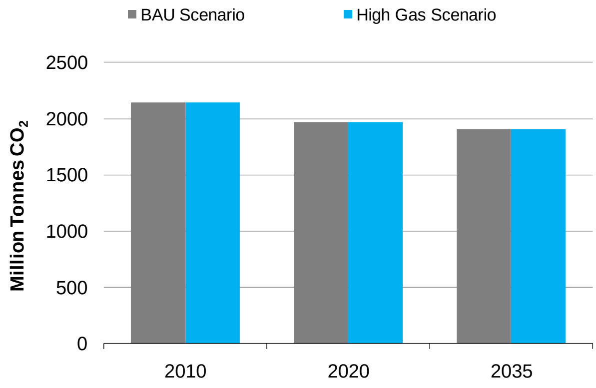


Source: APERC Analysis (2012)

Additional gas consumption in each economy in the High Gas Scenario depends not only on the economy's own additional gas production, but also on the gas market situation in the APEC region. The limiting factor for US gas production is the limited domestic consumption. Under BAU, domestic gas consumption reaches saturation in all sectors. Therefore, all additional gas production above BAU must be exported as LNG. Exports via pipeline are unlikely since both the neighboring economies of Mexico and Canada are net exporters of gas to the US. Owing to the large capital investment for LNG, the long development horizon and the lack of existing infrastructure, gas production does not materially increase under the High Gas Scenario until after 2020. Increasing gas production would seek to boost US economic growth.

Additional gas in the High Gas Scenario was assumed to replace coal in electricity generation. Gas has roughly half the CO_2 emissions of coal per unit of electricity generated. Since the US electricity sector has no room for further gas utilization there is no domestic benefit in reducing CO_2 emissions. However, significant CO_2 emissions reductions exist for LNG importing economies within APEC (see China High Gas Scenario). With a more abundant LNG supply at no additional cost there is much potential for coal to gas switching in the power sector for the LNG importing economies within APEC. Figure US10 shows the CO_2 emissions under the High Gas Scenario are unchanged from BAU.

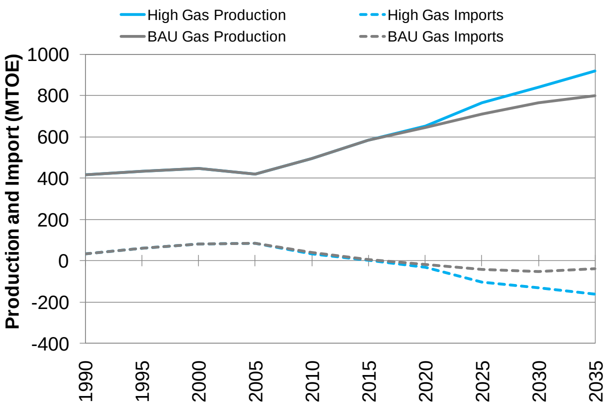
Figure US10: High Gas Scenario – CO_2 Emissions from Electricity Generation



Source: APERC Analysis (2012)

Figure US11 shows the High Gas Scenario production and imports. Gas exports increase from 30 Mtoe under BAU to around 155 Mtoe by 2035.

Figure US11: High Gas Scenario – Production and Imports



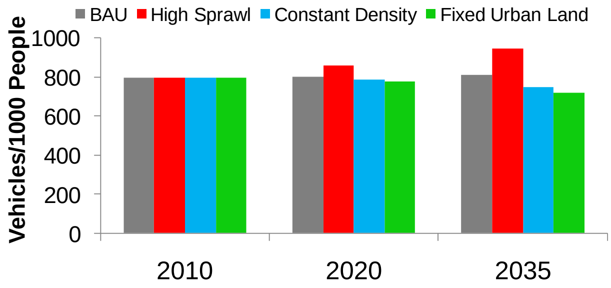
Source: APERC Analysis (2012)

ALTERNATIVE URBAN DEVELOPMENT SCENARIOS

To understand the impacts of future urban development on the energy sector, three alternative urban development scenarios were developed: 'High Sprawl', 'Constant Density', and 'Fixed Urban Land'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure US12 shows the change in vehicle ownership under BAU and the three alternative urban development scenarios. Urban planning has a direct effect on the expected level of vehicle saturation in long term vehicle ownership. Under BAU, US vehicle ownership is near saturation. The change in vehicle ownership under the different urban planning scenarios is significant.

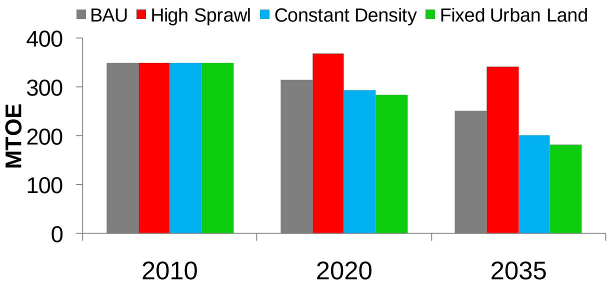
Figure US12: Urban Development Scenarios – Vehicle Ownership



Source: APERC Analysis (2012)

Figure US13 shows the change in light vehicle oil consumption under BAU and the three alternative urban development scenarios. The impact on oil consumption in the light vehicle fleet is compounded by a change in urban living and in the distances vehicles travel. In compact cities, travel distances per vehicle are typically lower than in sprawling cities.

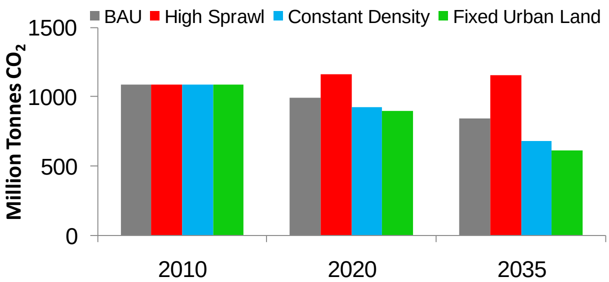
Figure US13: Urban Development Scenarios – Light Vehicle Oil Consumption



Source: APERC Analysis (2012)

Figure US14 shows the change in light vehicle CO_2 emissions under BAU and the three alternative urban development scenarios. The impact of urban planning on CO_2 emissions is similar to the impact of urban planning on energy use, since there is no significant change in the mix of fuels used under any of these cases.

Figure US14: Urban Development Scenarios – Light Vehicle Wheel-to-Tank CO_2 Emissions



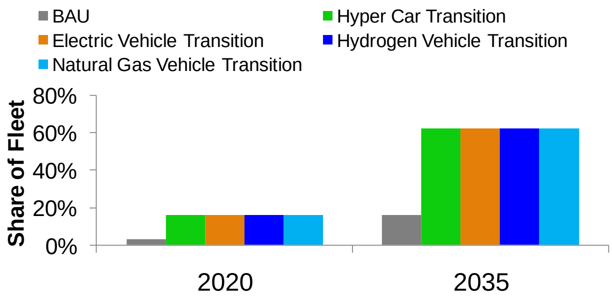
Source: APERC Analysis (2012)

VIRTUAL CLEAN CAR RACE

To understand the impact of vehicle technology on the energy sector, four alternative vehicle scenarios were developed: 'Hyper Car Transition' (ultra-light conventionally-powered vehicles), 'Electric Vehicle Transition', 'Hydrogen Vehicle Transition', and 'Natural Gas Vehicle Transition'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure US15 shows the evolution of the vehicle fleet under BAU and the four 'Virtual Clean Car Race' scenarios. By 2035 the share of the alternative vehicles in the fleet reaches around 62% compared to about 16% in BAU scenario. The share of conventional vehicles in the fleet is thus only about 38%, compared to about 84% in BAU scenario.

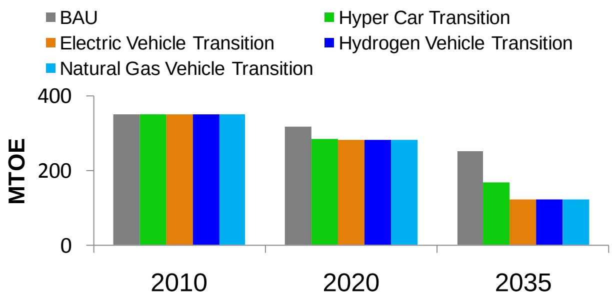
Figure US15: Virtual Clean Car Race – Share of Alternative Vehicles in the Light Vehicle Fleet



Source: APERC Analysis (2012)

Figure US16 shows the change in light vehicle oil consumption under BAU and the four alternative vehicle scenarios. Oil consumption drops by 52% in the Electric Vehicle Transition, Hydrogen Vehicle Transition, and Natural Gas Vehicle Transition scenarios compared to BAU by 2035. The drop is large as these alternative vehicles use no oil. Oil demand in the Hyper Car Transition scenario is also significantly reduced compared to BAU—down 34% by 2035—even though these highly-efficient vehicles still use oil.

Figure US16: Virtual Clean Car Race – Light Vehicle Oil Consumption

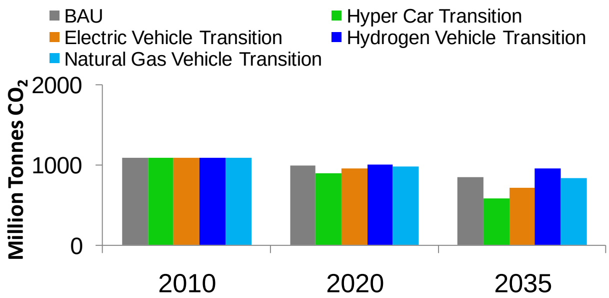


Source: APERC Analysis (2012)

Figure US17 shows the change in light vehicle CO_2 emissions under BAU and the four alternative vehicle scenarios. To allow for consistent comparisons, in the Electric Vehicle Transition and Hydrogen Vehicle transition scenarios the change in CO_2 emissions is defined as the change in emissions from electricity and hydrogen generation. The emissions impacts of each scenario may differ significantly from their oil consumption impacts, since each alternative vehicle type uses a different fuel with a different level of emissions per unit of energy.

In the US, the Hyper Car Transition scenario is the clear winner in terms of CO_2 emissions savings, with an emissions reduction of 31% compared to BAU in 2035. In addition, both Electric Vehicle Transition and Natural Gas Vehicle Transition scenarios offer savings in emissions of 15% and 2% respectively compared to BAU in 2035. In contrast, the Hydrogen Vehicle Transition scenario increases emissions 12%. This is principally because hydrogen production from steam methane reforming (from hydrocarbon fuels) has high emissions from the fuel production and distribution process. (To facilitate fair comparisons, the Electric Vehicle Transition and Hydrogen Vehicle Transition scenarios assumed no additional non-fossil utilization for their energy production.)

Figure US17: Virtual Clean Car Race – Light Vehicle CO_2 Emissions



Source: APERC Analysis (2012)

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