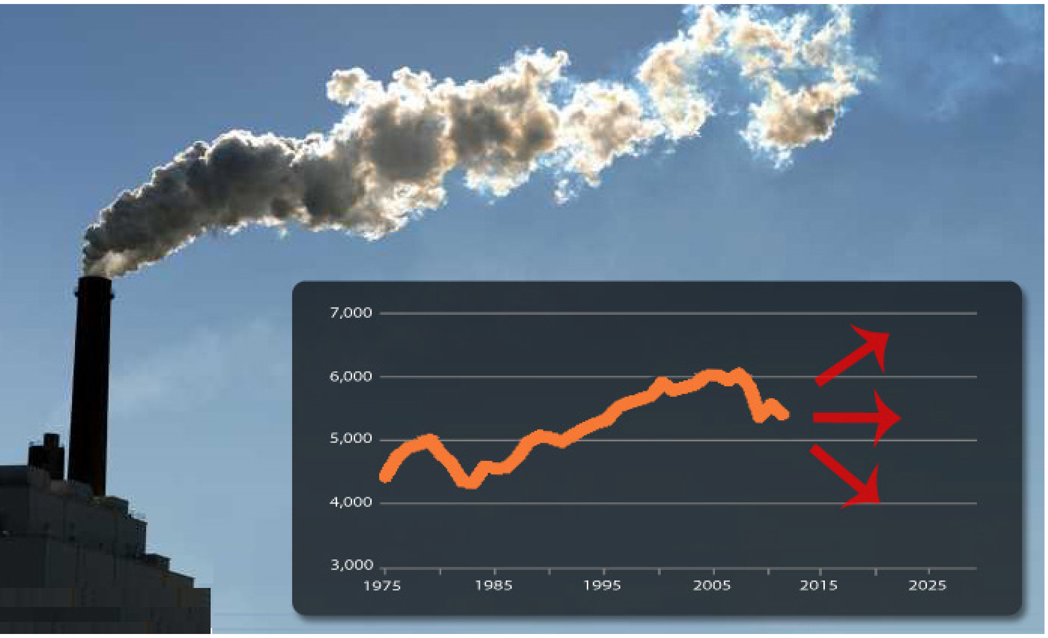
Can U.S. Carbon Emissions Keep Falling?



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Summary

U.S. carbon emissions are down, but the decline is unlikely to continue.

A Climate Central analysis of the American energy economy shows that the nearly 9 percent reduction in annual carbon emissions in the U.S. since 2005 is unlikely to continue in the years ahead without major departures from the ways energy is currently produced and used.

Recent declines in carbon emissions are the result of a combination of factors including the recession, increased natural gas production and the related decline in coal-fired electricity generation, continuing improvements in efficiencies of energy use, and growth in renewables, particularly wind power. The recession, however, appears to be the most significant factor in the decline. Consequently, as the economy rebounds the fall in emissions is likely to be neutralized or overtaken by growing population and incomes that will drive increased demand for energy-using appliances, air conditioners, TVs, personal electronic devices, cars, and other amenities. In the face of such growth and the 80 percent reliance of the U.S. on fossil fuels for energy today, modest improvements in energy efficiencies and expansions of lower-carbon energy alternatives will not provide the level of change in the energy economy needed for carbon emissions to fall by 2050 to a level that most climate scientists believe is needed to avoid severe impacts of climate change.

Key findings include:

– Recent reductions in coal generated electricity, driven primarily by extremely low natural gas prices, have left the existing U.S. fleet of coal-fired power plants operating at only about 50 percent capacity. Gas prices will not remain at historic lows, however, and eventual price increases will make firing up idle coal capacity more competitive, leading to increased CO_2 emissions.

– Doubling new car MPG by 2025 will produce about a 40 percent reduction in overall fleet gasoline consumption but not more than this since new cars are a small fraction of the total fleet. This 40 percent reduction assumes that the total number of vehicle miles driven by a growing population will be no higher than today, which is unlikely. Historically, increases in total miles driven have more than offset increases in car and light truck MPGs, resulting in increased gasoline consumption and carbon emissions.

– If the following hypothetical energy-related changes occur in the U.S. between now and 2035:

- the total number of miles driven by cars and light trucks stays constant at today's level while the average MPG for new cars increases to over 55 MPG in 2035,

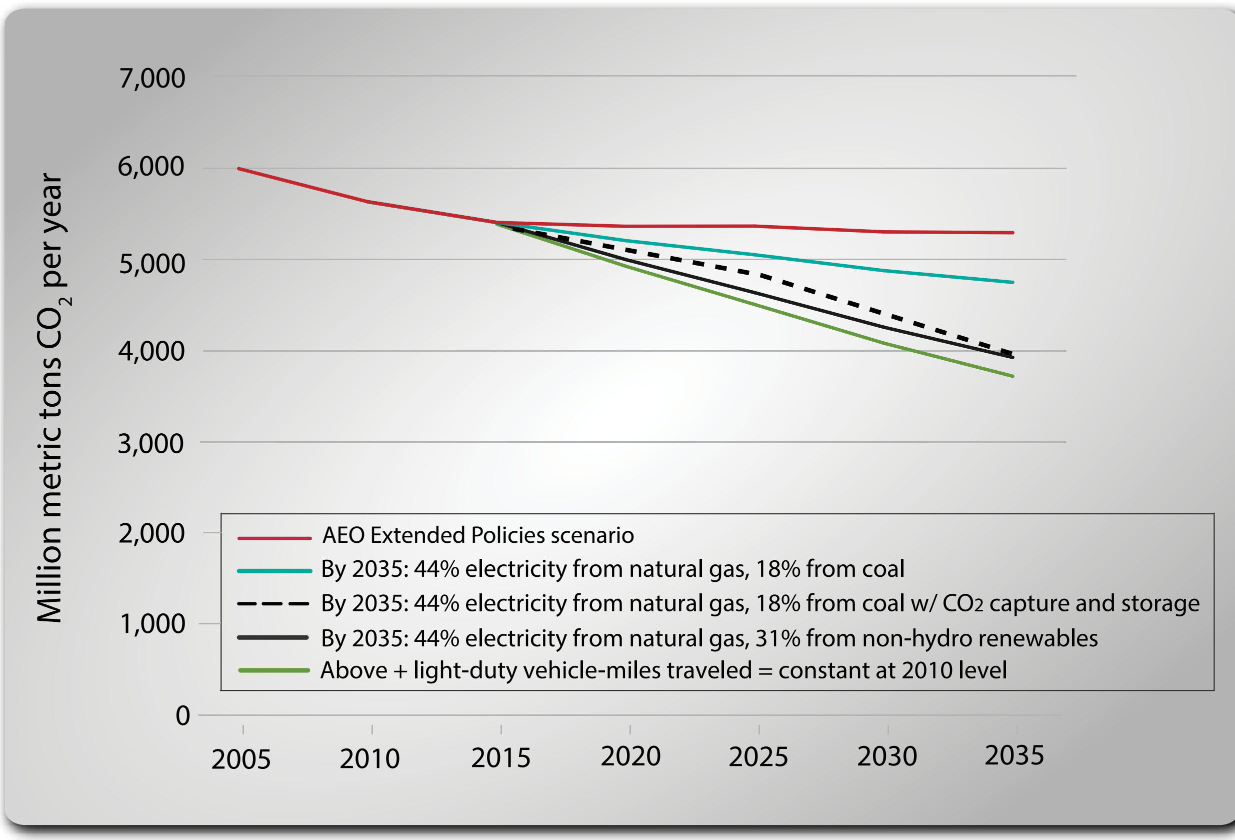
- gains continue to be made in the efficiencies of residential, commercial, and industrial energy-using equipment,

- the share of natural gas electricity ramps up from 29 percent today to 44 percent in 2035, with a corresponding reduction to 18 percent in coal's share,

- all coal-fired power plants in 2035 are operated with CO_2 capture and storage or alternatively, renewables grow from 5 percent of electricity today to 31 percent by 2035, replacing coal;

then U.S. CO_2 emissions in 2035 will decline to 38 percent below the 2005 level. Most climate scientists believe that emission reductions of at least 80 percent of the 2005 level will be needed in the U.S. and other industrialized countries by 2050 to avoid the most dangerous impacts of climate change.

Only Major Changes in the Energy System Can Begin to Drive Down CO_2 Emissions at the National Level



The upper line shows U.S. energy-related CO_2 emissions projected in the AEO Extended Policies scenario (EIA, 2012b). The additional lines describe a hypothetical alternative scenario involving aggressive expansion of natural gas power generation, coal with CO_2 capture and storage, expanded renewable electricity, and/or reduced vehicle-miles traveled.

Can U.S. CO_2 emissions keep falling?

Total U.S. fossil fuel CO_2 emissions dropped nearly 9 percent from 2005 to 2011 (Figure 1). This would appear to be great news in the fight to limit global warming. In fact, the percentage drop in total emissions since 2005 is more than half the level of reduction that was targeted for 2020 (17 percent reduction compared to 2005) in the American Clean Energy and Security Act of 2009, also called the Waxman-Markey "cap and trade" bill. That bill, which died in the Senate, additionally called for an 83 percent reduction in emissions by 2050 (relative to 2005), a level that most climate scientists believe would ensure that the U.S. was doing its part in the global effort to reduce greenhouse gas emissions to a level that would limit damages from climate change.

The recession has been a major contributing factor to the recent decline in emissions (see Box 1), but other forces – including energy efficiency gains, growth in renewables and natural gas, and the decline in coal's portion of electricity generation – are also at work. This raises the possibility that the decline could continue even after the economy rebounds, and that significant reductions might continue going forward.

Such optimism ignores several fundamental features of the American energy economy.

The first is the sheer enormity of our dependence on fossil fuels. The U.S. is the 2nd largest energy user in the world (18 percent of global energy) next to China (21 percent), and more than 80 percent of U.S. energy use is carbon-rich fossil fuel (Figure 2). The country has trillions of dollars invested in infrastructure designed to supply or use fossil fuels: power plants, coal mines, oil and gas wells, refineries, vehicle fleets, houses, office buildings, and manufacturing facilities. Most of this infrastructure is built to be used for decades. Unless such infrastructure is retired earlier than anticipated in favor of lower carbon-emitting infrastructure, fossil fuels are likely to continue to dominate energy use.

Second is our growing population and even faster growing per-capita wealth (Figure 3). As the economy recovers, the ever-larger number of increasingly affluent energy users demanding an ever-growing number of energy-using products and services will put upward pressure on the country's energy use. The growth in computers and cell phones is just one small example (Figure 4).

U.S. CO_2 Emissions from Energy

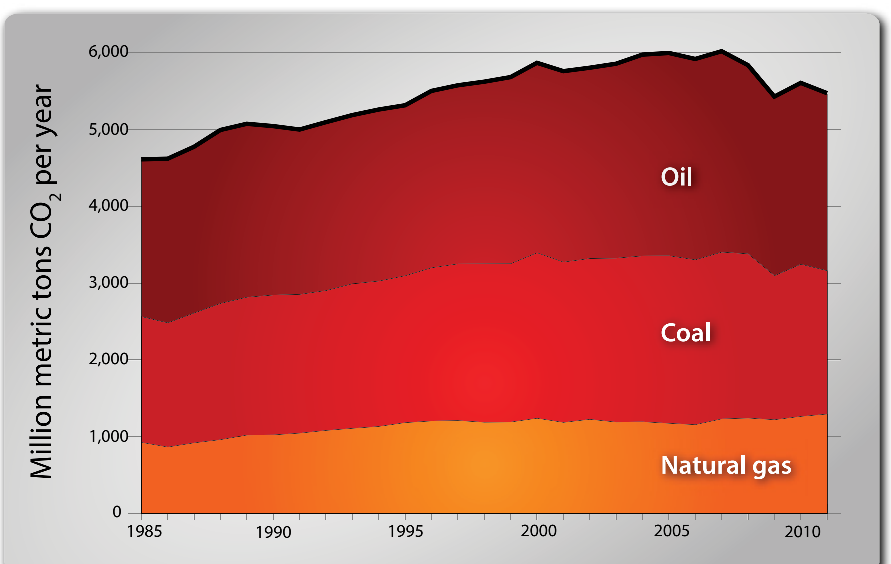


Figure 1. *Annual fossil fuel CO_2 emissions in U.S. rose steadily from 1985 to 2007, after which they fell each year except for a slight rebound in 2010. Oil use accounts for the largest share of emissions, followed by coal and then natural gas. Source: (EIA, 2012a).*

Fossil Fuels Dominate the U.S. Energy Economy

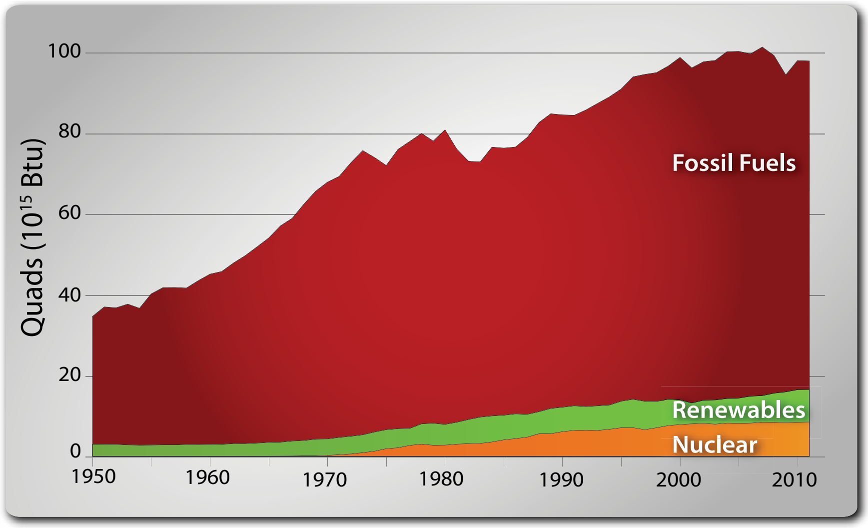


Figure 2. *U.S. energy use by source. Source: (EIA, 2011) .*

The number of cars on the road in the U.S. has grown steadily for four decades, from about 100 million in 1970 to 250 million in 2010 (ORNL, 2011), and the Energy Information Administration (EIA) projects that the number of new cars purchased in the coming 25 years will follow the long-term historical trend (Figure 5). More importantly from the standpoint of energy use, the EIA projects that the number of miles traveled by light-duty vehicles (cars, vans, SUVs, light trucks) will grow by a ***trillion*** miles between now and 2035 (Figure 6). The growth in light-duty vehicle population and in vehicle miles traveled could certainly end up being slower than the EIA projects, but dramatic, even unprecedented societal changes would be required to reverse more than 40 years of annual driving increases, particularly in the context of a growing population.

More People with More Money to Spend on Energy-Using Goods and Services

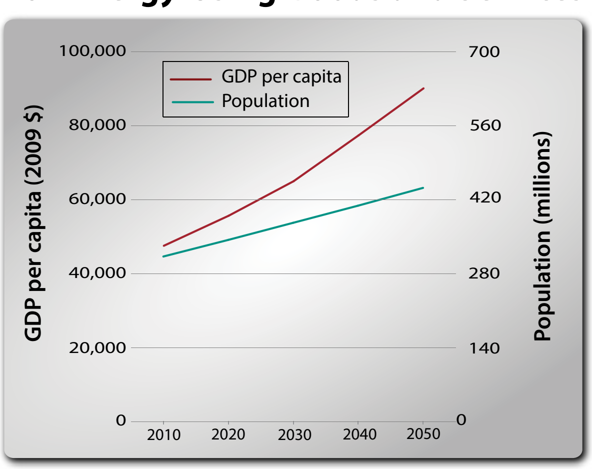


Figure 3. *Projected U.S. population growth assuming low net international migration (U.S. Census Bureau, 2009). Also, per-capita gross domestic product (in constant dollars) (PCW, 2012) which is projected to grow faster than population.*

Use of Personal Electronics Continues its Steady Rise

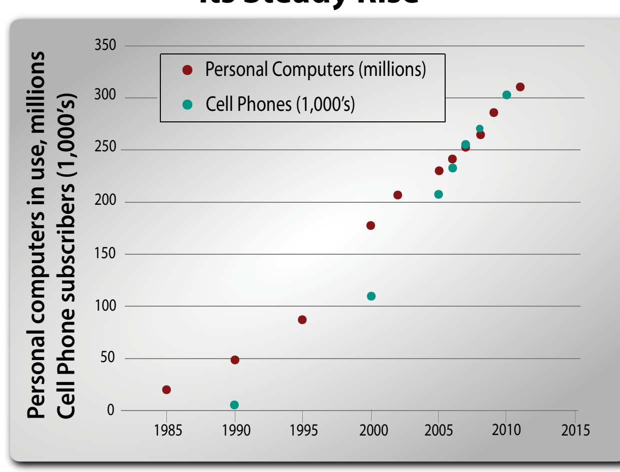


Figure 4. *Sources: CIAI, 2012 and U.S. Census Bureau, 2012.*

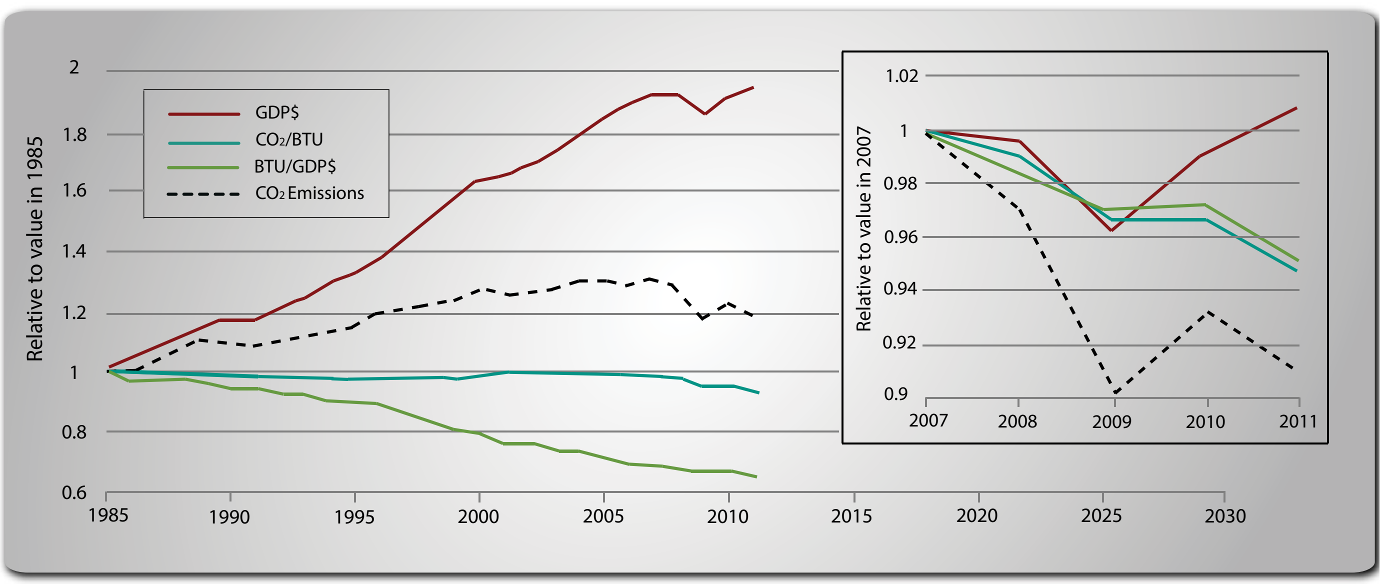
Box 1: Reductions in Gross Domestic Product Account for the Most Significant Share of the Recent Declines in CO_2 Emissions

U.S. CO_2 emissions in a given year can be viewed as the product of three quantities: 1) U.S. gross domestic product for that year, 2) the total amount of energy used per dollar of GDP that year (the energy intensity of the economy), and 3) the CO_2 emissions per unit of energy used that year (the carbon intensity of energy):

$$CO_2 \text{ Emissions} = \text{GDP\$} \times \frac{\text{Energy Use}}{\text{GDP\$}} \times \frac{CO_2 \text{ Emissions}}{\text{Energy Use}}$$

The figure below shows how all four of these quantities have been changing since 1985. Gross domestic product, the energy intensity of the economy, and the carbon intensity of energy all show smooth trends from 1985 until 2007. Correspondingly, CO_2 emissions, the product of these 3 quantities, also grew smoothly during this time (dashed line). But CO_2 emissions declined sharply after 2007, leveling off for 2009-2011. The inset figure strongly suggests that the dominant reason for the drop in CO_2 emissions after 2007 was the large drop in GDP. A secondary contributor was the reduction in carbon intensity that began around that time.

Changes in Gross Domestic Product Strongly Influence CO_2 Emissions



Gross domestic product in constant dollars (GDP\$), carbon intensity of energy (CO_2/BTU), energy intensity of the economy (BTU/GDP\$), and CO_2 emissions are each plotted relative to their 1985 values to highlight trends. In the inset, the quantities are plotted relative to their 2007 levels.

Recent Declines in Driving are Not Likely to be Sustained in the Face of Population Growth, Increased Wealth and Lack of Alternatives

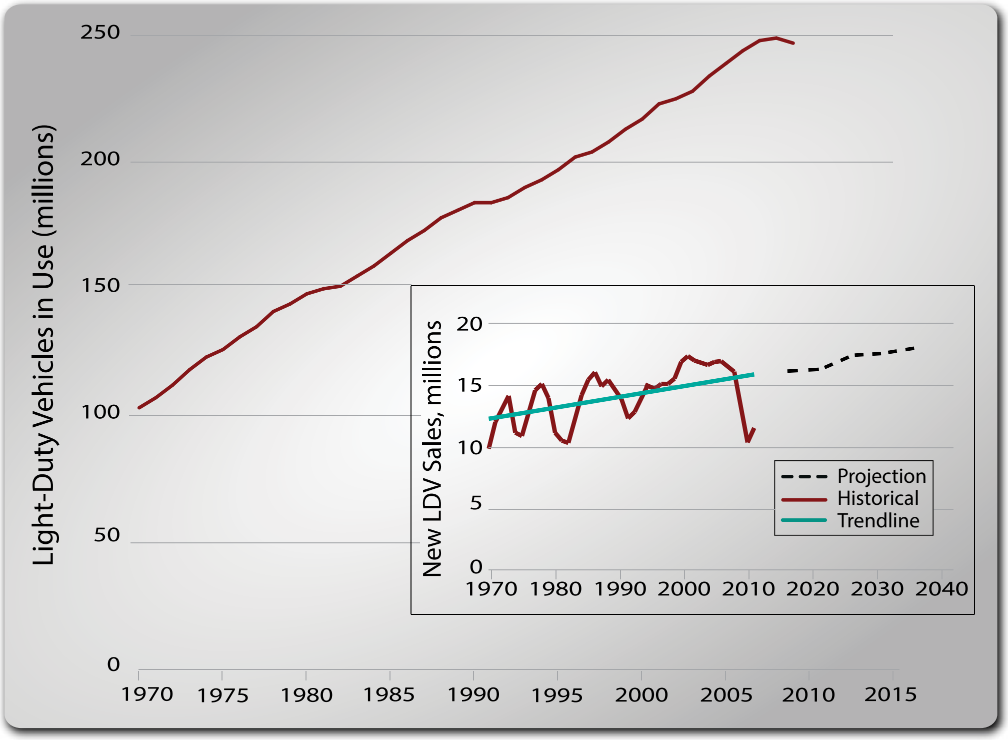


Figure 5. *The number of cars in use has increased steadily since 1970 (ORNL, 2011). The inset shows new car sales history (ORNL, 2011) and as projected in the AEO Extended Policies scenario (EIA, 2012b).*

Are business-as-usual trends in energy efficiency and growth in natural gas and renewables enough to keep CO_2 emissions falling?

There are a variety of market forces at work and government policies in effect or in the pipeline, that promise to improve the efficiency with which Americans use energy and to shift energy supplies to less carbon-intensive energy forms like natural gas and renewables. These are at least partially responsible for the recent decline in greenhouse gas emissions. Will these by themselves be able to deliver much more significant reductions in carbon emissions in the future? (see Box 2)

It is difficult to make a case for this.

Consider efficiency improvements, such as the new CAFE standards for cars or new appliance efficiency standards for refrigerators, air conditioners and other equipment. Big improvements in efficiencies of individual cars and appliances can be expected from these measures. For example, under the new CAFE standards, the fuel economy of new light-duty vehicles in 2025 will average nearly 55 mpg, or double the new light-duty vehicle average today. A new car in 2025 traveling the same distance as a new car today would use only half as much gasoline and generate half the carbon pollution.

But working against this improvement is the fact that new cars represent only a small fraction of cars on the road – in 2007 (before the recession started) new car sales accounted for about 7 percent of the approximately 245 million light-duty vehicles in use that year (ORNL, 2011). Because of this, the fuel economy average for all cars on the road lags the CAFE standard. For example, the CAFE standard for new cars in 2009 was 29 mpg, while the average for all cars on the road that year was 20.4 mpg (ORNL, 2011).

Box 2: Why We Use the Annual Energy Outlook Extended Policies Scenario as a Starting Point

To understand whether or not current reductions in carbon emissions might continue in the absence of major unforeseen market or policy changes, the Annual Energy Outlook (EIA, 2012b) of the Energy Information Agency provides a reasonable point of departure. The AEO projects energy production and use under 31 alternative future scenarios, including one called the "Extended Policies" scenario, which is designed to be representative of a "business-as-usual" future. The report Appendix provides more discussion of the AEO and its Extended Policies scenario. The key underlying assumption for the Extended Policies scenario is that energy supply and demand behave out to 2035 as if current laws and regulations or those that are clearly in the pipeline for adoption remain in effect until then, but no fundamentally new policies or market changes come into play that would impact energy or energy-related greenhouse gas emisions.

The EIA has been criticized for failing to predict future energy developments, most recently for failing to project the rapid growth of wind and natural gas electricity generation. These criticisms are accurate as far as they go, but they often overlook the point of the AEO, which is to steer clear of guessing about future policy developments. In that respect, the AEO Extended Policies scenario is ideal for our purposes, which is to illustrate what a future is likely to look like without any action taken to help shape it.

Americans May Drive a TRILLION More Miles Per Year by 2035

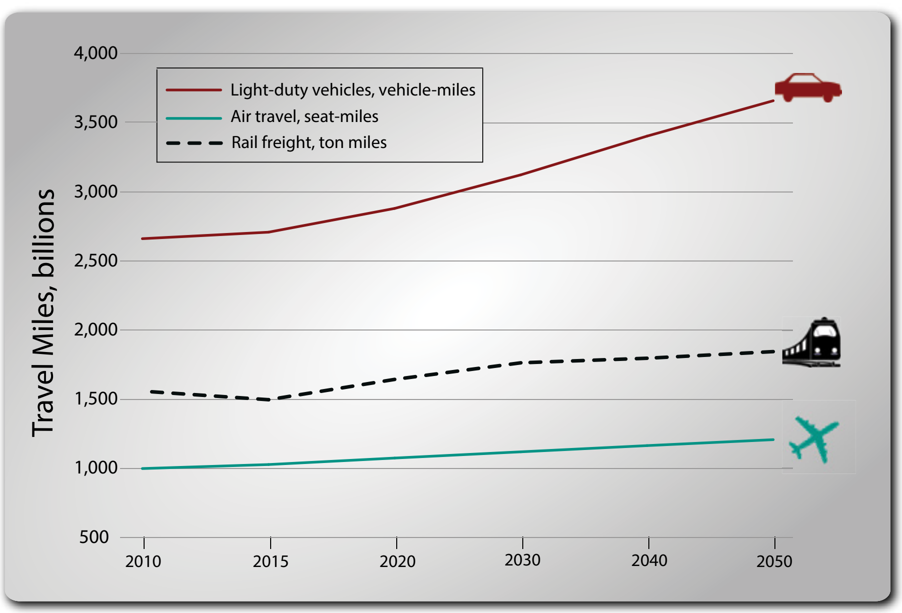


Figure 6 . *AEO projections (Extended Policies scenario) to 2035 of light-duty vehicle-miles driven, airplane seat-miles flown, and ton-miles of rail freight moved (EIA, 2012b).*

With the new CAFE standards, the average fuel economy of all light-duty vehicles on the road is projected by the EIA to increase from about 20 mpg in 2010 to 27.5 mpg in 2025 (EIA, 2012b). Assuming increasingly aggressive new CAFE standards after 2025, the average fuel economy of light-duty vehicles on the road could reach 36 mpg by 2035 (EIA, 2012b). The latter would be about a 44 percent reduction in fuel consumed per vehicle-mile traveled compared with the average in 2010 – a significant reduction.

But with projected population and income growth, total vehicle-miles traveled is likely also to increase, once the economy regains some steam. In fact, historically the rate of increase in vehicle-miles traveled has outpaced the rate of increase in average vehicle fuel economy, resulting in steadily rising national gasoline consumption (Figure 7) and associated carbon pollution. Going forward, the EIA projects vehicle miles traveled by light-duty vehicles to increase from 2.66 to 3.66 trillion between 2010 and 2035 (Figure 6), an increase of 37 percent. This would offset much of the 44 percent projected reduction in fuel consumed per mile by light-duty vehicles. (We analyze an alternative scenario below.)

When combined with projected increases in other modes of travel (air, rail, truck) for the coming decades (Figure 6), overall fuel use to move people and goods in the U.S. is projected by the EIA to be only 8 percent lower in 2035 than in 2010 in its Extended Policies scenario (EIA, 2012b). And most of the fuel used will be of the carbon-emitting petroleum-derived type. Some transportation will be fueled by electricity, but electric vehicles are unlikely to account for a significant share of vehicle-miles driven in the next couple of decades. In any case, carbon emission reductions from electric cars will be less than they could be if fossil fuels continue to dominate electricity generation (Larson and Kenward, 2012).

Similar trends can be anticipated in the residential and commercial sectors, where the EIA projects that energy savings from more efficient appliances and buildings will be eroded by their slow rate of penetration and ever-increasing numbers.

More Driving has Wiped-out Potential Emission Reductions from Increased MPG

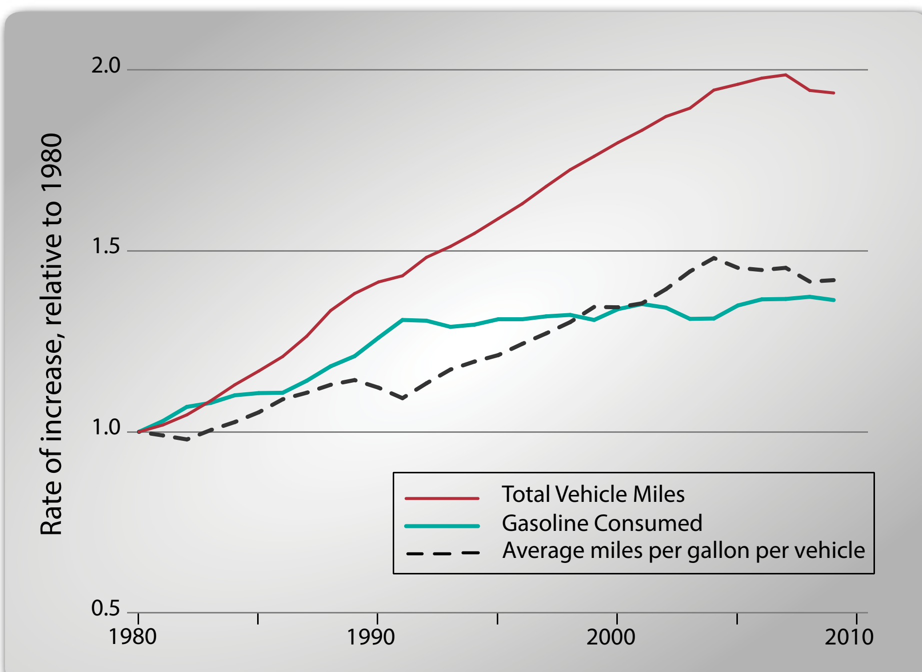


Figure 7. *In the U.S., total vehicle miles traveled (VMT) by light-duty vehicles and their average fuel economy (MPG) on the road both increased from 1980 to 2009, but VMT increased faster than MPG, resulting in an increase in gasoline consumption by light-duty vehicles. Source: ORNL, 2011.*

The number of major appliances grows slightly faster than population in the EIA's Extended Policies scenario (Figure 8). As a result, in spite of efficiency improvements, CO_2 emissions attributed to residential-sector equipment remain roughly constant from 2015 to 2035 (Figure 9).

If energy supplies were less carbon intensive, CO_2 emissions would be lower. The increasing displacement today by natural gas of coal, traditionally the primary U.S. fuel for electricity generation, is a good example. CO_2 emissions per kilowatt-hour generated using gas are half or less those with coal. Shifting from gas to coal has contributed to the recent national emissions reduction, and the EIA's Extended Policies scenario projects continued growth in electricity from natural gas.

The recent shift toward more electricity from gas has been due to a drop in gas prices resulting from a large increase in natural gas supplies delivered via hydraulic fracturing of shale formations. The average price of gas to electric generators today is around $3 per thousand cubic feet (TCF), an unprecedented low level. Environmental concerns with "fracking" aside, gas prices are unlikely to remain at this level. (The EIA projects gas prices will begin rising in the middle of this decade and reach $6.5 per TCF in constant dollars by 2035.)

As gas prices rebound, even modestly, and demand for electricity grows, driven by growth in population and wealth, the existing fleet of coal plants, which today are operating at under 50 percent of capacity on average, are likely to maintain an important role in electricity generation.

The EIA projects that the share of electricity generated by coal will be 37 percent in 2035, down from 42 percent in 2011 and about the level seen for the first quarter of 2012. Notably, with total electricity demand projected to increase in coming decades, the actual amount of electricity generated from coal in 2035 in the Extended Policies scenario is more than the amount coal generated in 2011.

More People with More Money Buy More and Bigger Appliances that Need Energy

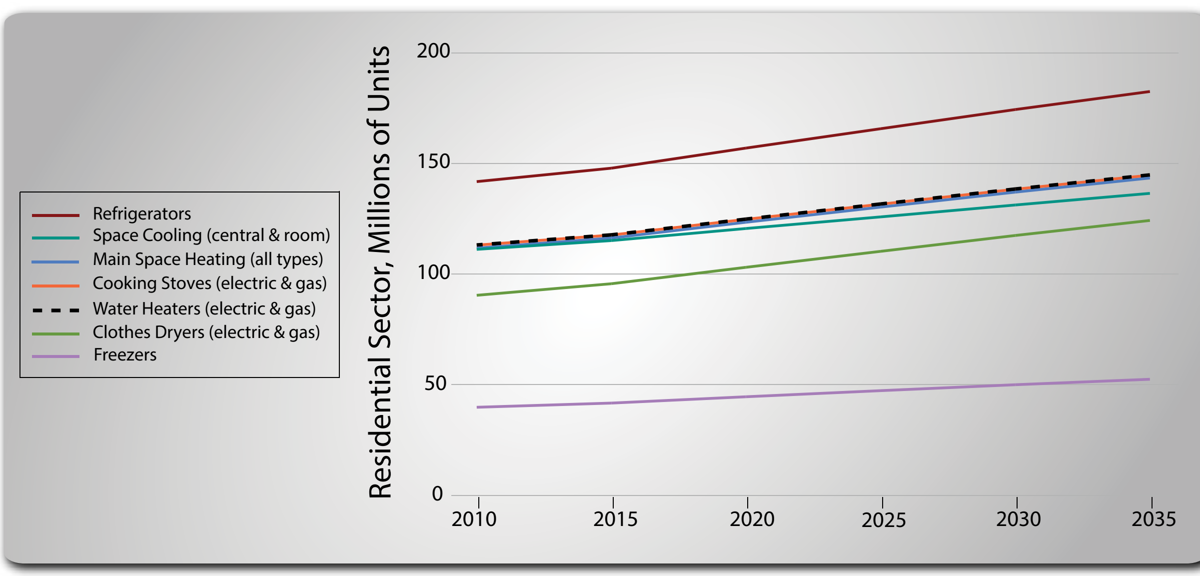


Figure 8. *Residential-sector energy-using equipment populations in U.S. projected in AEO Extended Policies scenario (EIA, 2012b).*

Efficient Appliances are Critical, but Not Enough by Themselves to Reduce Carbon Emissions

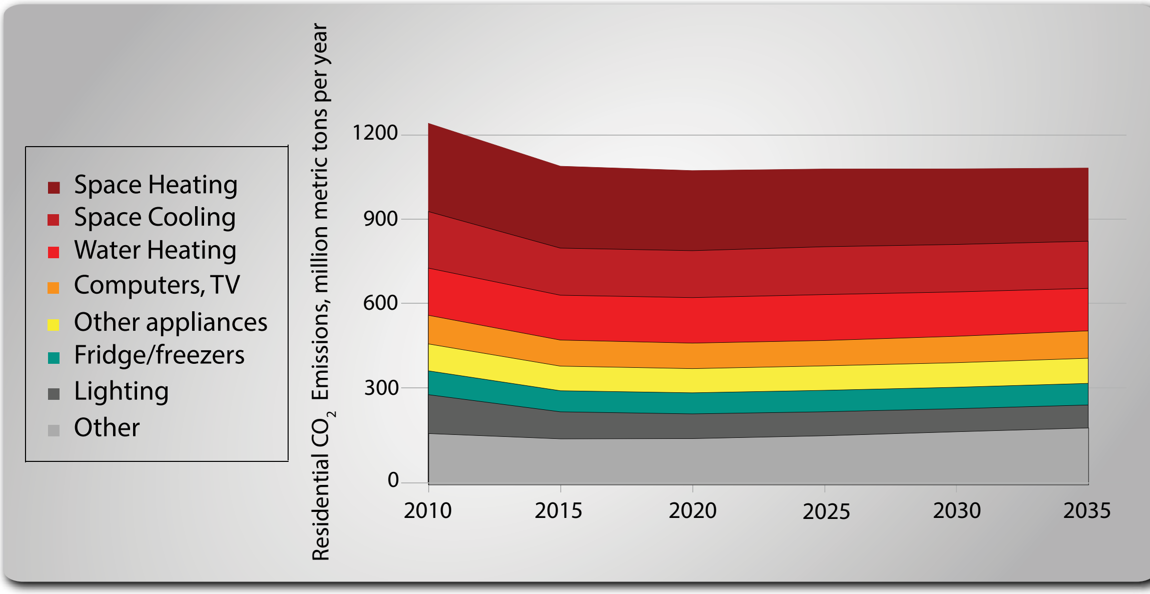


Figure 9. Projections to 2035 of CO_2 emissions attributed to residential energy-using equipment in the Energy Information Administration's Annual Energy Outlook Extended Policies case (EIA, 2012b). See Figure 8 for assumed equipment populations.

Hypothetical Alternative Emissions Pathways

We have used the AEO Extended Policies scenario as a suggestion of what the future might hold for CO_2 emissions in the U.S. without significant policy or market changes. But, of course, such changes might occur. We develop some hypothetical alternatives to quantify the magnitude of possible emissions reductions resulting from significant changes to the energy system. Specifically, we consider higher natural gas use for power generation, coal-fired power generation with CO_2 capture and storage, aggressively-expanded renewable electricity supply, and reductions in annual vehicle-miles traveled.

Starting with the same level of demand for energy services as in the AEO Extended Policies scenario, we first consider an even more significant shift from coal to natural gas in power generation than in the AEO scenario. For concreteness, we examine a scenario in which natural gas grows to an extent that it displaces by 2035 half of the power generated using coal in the AEO scenario. Natural gas would then be providing 44 percent of all electricity in 2035, up from 29 percent in the first quarter of 2012. Coal would be providing 18 percent. Achieving this level of natural gas use would require essentially all of the added gas supplies expected to be available from hydrofracking between 2010 and 2035 to be used exclusively for power generation. This would likely put upward pressure on gas prices, but is at least technically feasible. With this scenario, national CO_2 emissions would be about 13 percent lower in 2020 than in 2005 (Figure 10), which can be compared to the 17 percent reduction target in the proposed Waxman-Markey bill. Emissions would be 21 percent below the 2005 level by 2035.

If in addition to the larger shift to natural gas in our hypothetical scenario, the technology of CO_2 capture and storage (CCS) were introduced for coal power generation, coal would continue to play a major role in electricity supply while CO_2 emissions could be further reduced. For specificity, if CCS were to be implemented starting in 2015 (with 5 percent of capacity so equipped that year) and ramped up rapidly (to 20 percent of capacity in 2020 and 100 percent of capacity by 2035), U.S. CO_2 emissions in 2035 would be 33 percent less than in 2005 (Figure 10). The volumes of CO_2 that would need to be stored underground in this scenario would be

Only Major Changes in the Energy System Can Begin to Drive Down CO_2 Emissions at the National Level

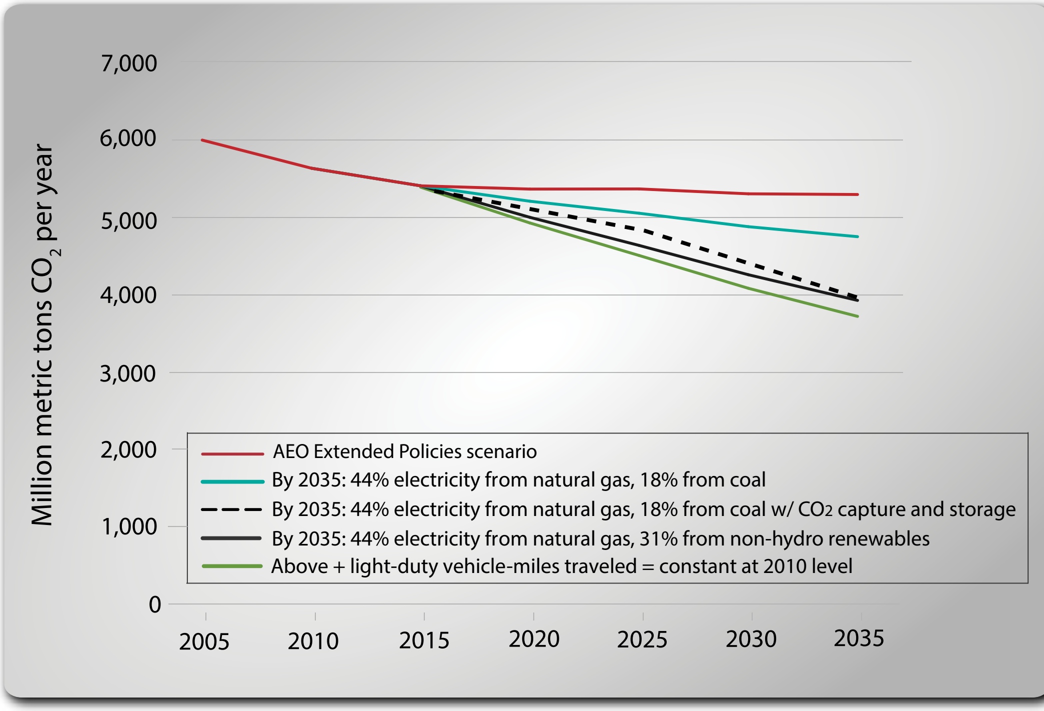


Figure 10. *The upper line shows U.S. energy-related CO_2 emissions projected in the AEO Extended Policies scenario (EIA, 2012b). The additional lines describe a hypothetical alternative scenario involving aggressive expansion of natural gas power generation, coal with CO_2 capture and storage, expanded renewable electricity, and/or reduced vehicle-miles traveled. See discussion in text.*

A Major Expansion of Renewables Will Require Annual Investments Far in Excess of the Highest Levels Seen in the Past

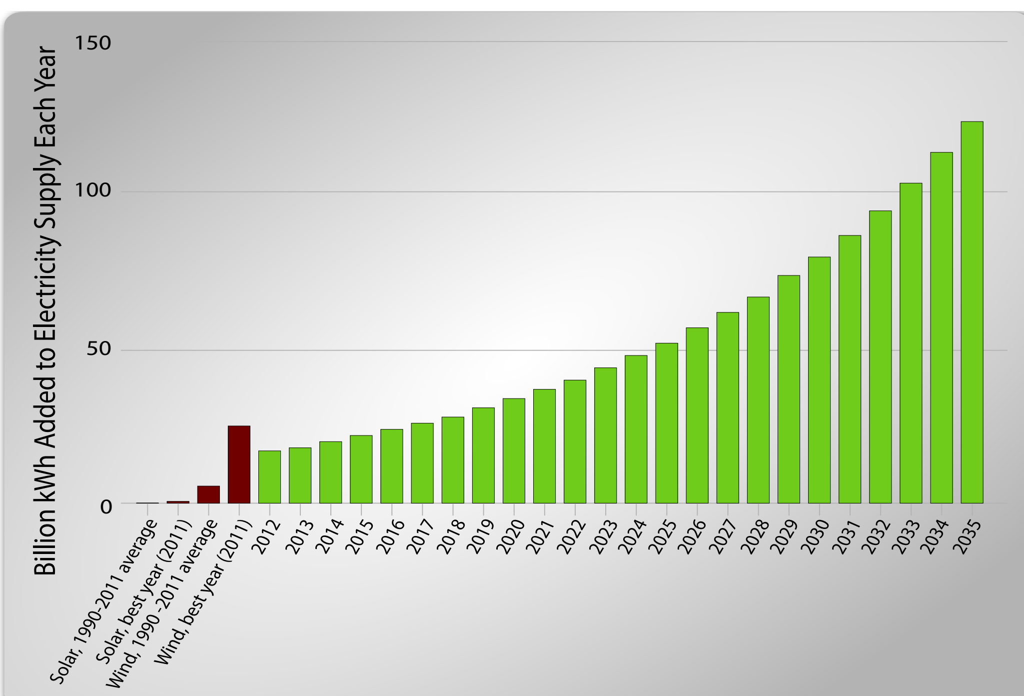


Figure 11. *Average and best historical annual wind and solar electricity additions (EIA, 2012a) compared with additions of non-hydro renewable additions that would be needed to achieve the scenario described in the text.*

substantial. For example, in 2020 some 7 million barrels per day of CO_2 would need to be stored. This would represent a major new industrial enterprise, as evidenced by the fact that total U.S. domestic oil production today is about 6 million barrels per day.

An alternative to CCS in our hypothetical scenario could be a rapid expansion in renewable electricity sources. If renewables were ramped up to completely replace coal by 2035, CO_2 emissions then would be 34 percent below the 2005 level in 2035. Achieving this level of renewables by 2035 would mean a huge ramp up in wind, solar, and other new renewable sources. Non-hydro renewables accounted for less than 5 percent of all electricity generated in the U.S. in 2011, and historically the largest single-year addition of electricity from these sources was 28 billion kilowatt-hours in 2011, of which 25 billion was from wind and 0.6 billion was from solar (EIA, 2012a). Figure 11 compares these historical benchmarks against the annual additions of non-hydro renewables that would achieve the 34 percent national reduction in CO_2 emissions by 2035. Another way to express the numbers in Figure 11 is that expansion would be required at an annual average rate more than double the largest single-year addition ever, every year for the next 23 years – perhaps not impossible, but certainly unprecedented. And even if a 34 percent reduction were achieved, it would still fall far short of the 83 percent reduction by 2050 targeted in the Waxman-Markey bill and believed to be needed to help minimize damage from climate change.

As a final element of our hypothetical scenario, in addition to more natural gas, coal with CCS and/or expanded renewables, what if America's driving habits change such that the total number of vehicle miles driven each year stabilizes at the 2010 level (2.7 trillion miles), rather than growing another trillion miles by 2035, as projected in the EIA's Extended Policies scenario? In this case, U.S. CO_2 emissions would reach 38 percent below 2005 levels by 2035, a meager additional reduction in our hypothetical scenario (Figure 10). The added reductions are not especially large because the AEO Extended Policies scenario already assumes that CAFE standards lead to relatively high fuel economies for light-duty vehicles.

Conclusion

The recent drop in U.S. carbon emissions is reminiscent of a similar drop that began in 1980 in the wake of the Iranian hostage crisis. That drop in emissions lasted about 4 years: once the shock from skyrocketing oil prices subsided, the country began burning more and more fossil fuels each year. Fundamental forces that drove the increased fossil fuel use that caused the rising CO_2 emissions from 1985 to 2005 – a growing population and growing wealth – are forces that will continue to drive increased demand for energy services in the decades ahead. Combined with the enormous dependence of the U.S. energy economy on fossil fuels today, emissions are unlikely to continue to decline once the economy regains steam.

Business as usual improvements in the efficiency of energy use and shifting of energy supplies to less carbon-intensive sources will help limit future growth in CO_2 emissions, but will not lead to the U.S. achieving the levels believed by most climate scientists to be needed by mid-century in the U.S. and in other developed countries to limit damages from climate change.

Appendix: The EIA Annual Energy Outlook

The Annual Energy Outlook (AEO), produced by the Energy Information Agency (EIA), aims to inform energy decision-making by government policy makers and others. The EIA uses a very detailed energy economy model of the U.S., the National Energy Modeling System (NEMS), to project the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. The NEMS projections are developed using a market-based approach, subject to regulations and standards.

The most recent AEO (June 25, 2012) provides a useful explanation of the limitations of AEO projections:

> *Projections by EIA are not statements of what will happen but of what might happen, given the assumptions and methodologies used for any particular scenario. The Reference case projection is a business-as-usual trend estimate, given known technology and technological and demographic trends. EIA explores the impacts of alternative assumptions in other scenarios with different macroeconomic growth rates, world oil prices, and rates of technology progress. The main cases in AEO2012 generally assume that current laws and regulations are maintained throughout the projections. Thus, the projections provide policy-neutral baselines that can be used to analyze policy initiatives.*
>
> *While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies rather than representations of specific outcomes.*
>
> *Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Many key uncertainties in the AEO2012 projections are addressed through alternative cases.*
>
> *EIA has endeavored to make these projections as objective, reliable, and useful as possible; however, they should serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives.*

Keeping in mind these caveats, we have chosen to use the most recent AEO's "Extended Policies" scenario as representative of a future in which no major new policies are enacted that aim to significantly reduce greenhouse gas emissions. Unlike the AEO's "Reference Case" scenario, the Extended Policies scenario incorporates many significant policies that are under active discussion today, but which are excluded from the Reference scenario because they were technically not yet on the books as laws or regulations as of the end of 2011. In the Extended Policies scenario, the Reference case assumptions are amended to extend most existing energy policies and regulations that are scheduled by law to end by a specified date. It also assumes additional policies are put in place. Features that define the Extended Policies scenario include, but are not limited to, the following:

- In transportation, the average fuel economy of new light-duty vehicles increases to 62 mpg by 2035.
- In the residential sector, tax credits are permanently extended for selected end-use equipment (including furnaces, heat pumps, and central air conditioning), for renewable energy equipment (including PV installations, solar water heaters, small wind turbines, and geothermal heat pumps), and manufacturer tax credits for other appliances (including refrigerators, dishwashers, and clothes washers) are passed on to consumers at 100 percent of the tax credit value.
- In the commercial sector, investment tax credits are permanently available to businesses installing PV installations, solar water heaters, small wind turbines, geothermal heat pumps, and combined heat and power.
- Impacting the manufacturing sector and users of the manufactured products, additional rounds of tighter efficiency standards and tax credits are introduced for efficient residential and commercial products and for products not previously covered. Multiple new rounds of national building codes and standards are assumed to be introduced over the next 14 years. The size of investments in efficient industrial combined heat and power systems that qualify for an investment tax credit is increased.
- In renewable energy production, the production tax credit (PTC) available to wind power generators (2.2 c/kWh) is permanently extended, and a PTC of 1.1 c/kWh is made available for geothermal electricity (and some other types of renewable electricity). Additionally, various incentives for biofuels are made permanent, including a $1/gallon tax credit for biodiesel, a $1.01/gallon production tax credit for cellulosic ethanol, and a $0.54/gallon tariff on imported ethanol.

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