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A Clean Energy Bargain

More Jobs, Less Global Warming Pollution, and Greater Security for Less Than the Cost of a Postage Stamp

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NRDC

About NRDC

The Natural Resources Defense Council (NRDC) is a national nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at www.nrdc.org.

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Please note that the organizational affiliations are listed for identification purposes only. The results presented here do not necessarily reflect the views of the Doris Duke Charitable Foundation, the listed advisors or consultants, or their organizations, and NRDC takes sole responsibility for the conclusions and recommendations drawn from the modeling effort.

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Executive Summary

The United States took an important step toward economic recovery, environmental protection, and energy security when the House of Representatives passed the American Clean Energy and Security Act (ACES). This sound climate and clean energy legislation will protect the planet for less than the cost of a postage stamp a day per household, and represents a great investment in America's future—now it's up to the Senate to turn this bill into a law.

With the guidance of a group of expert advisors from academia, industry, labor, and non-governmental organizations, NRDC has sponsored an independent analysis of the impacts of the ACES bill, using two well-known national energy models.

This analysis confirms that ACES is a win-win for the economy and the environment. In addition to helping us avert the most catastrophic effects of climate change, ACES will encourage the use of emerging clean technologies, make us more energy efficient, reduce our reliance on foreign oil, and lessen our exposure to oil price shocks.

ACES is an Investment in Our Clean Energy Future

The challenges of global warming, an ailing economy, and our dependence on foreign oil highlight the need for a new generation of energy and environmental legislation. By combining a cap on global warming pollution with investments in clean energy and energy efficiency, the proposed "cap-and-invest" strategy can create hundreds of thousands of jobs while protecting the environment.

As part of our effort to define, model, and communicate this cap-and-invest strategy, NRDC used the NEMS-NRDC and MARKAL national energy models to examine the impact of ACES on our economy (for more information, see www.nrdc.org/cap2.0).

While no modeling results can be expected to predict the future perfectly, careful modeling can provide important insights and identify the potential impacts of specific policies. Key findings of our modeling effort include:

- **ACES will boost our economy:** ACES will drive \$300 billion of investments (through 2030) toward clean energy, creating hundreds of thousands of jobs in the process.
- **ACES is affordable**: The cost of ACES to American households will be less than the cost of a postage stamp per day.
- **ACES will make America more secure**: ACES can reduce oil imports by as much as 5 million barrels per day, improve our energy security, and reduce the risk of fuel price shocks. At today's price

of around $70 per barrel, that will mean more than $2 trillion (through 2050) that America will not send overseas for imported oil.

Our analysis also shows:

- Allowance prices will range from $12 to $16 in 2012, rising to $17 to $28 in 2020 and $28 to $57 in 2030.
- Complementary policies that promote greater investments in clean energy and energy efficiency have a significant role in keeping ACES affordable.
- Tightening targeted emissions reductions for 2020 from 17 percent below 2005 levels to 20 percent below 2005 levels would increase allowance prices just 6 percent.
- Promoting the adoption of more efficient vehicles and greater transportation efficiency (e.g., smart growth and better public transit) can have a large impact in both lessening our oil dependence and lowering the costs of avoiding dangerous global warming.

ACES Will Boost Our Economy

ACES WILL DRIVE APPROXIMATELY $300 BILLION TOWARD CLEAN ENERGY

Renewables account for approximately 10 percent of electricity generation in the United States, with hydropower taking the largest share. Under business-as-usual (BAU), the Energy Information Administration (EIA) estimates that renewables will increase their market share to approximately 15 percent by 2020 and remain at that level through 2030. Under ACES, NEMS-NRDC and MARKAL show that renewables could account for 17 to 22 percent of electricity generation in 2020 and 19 to 34 percent in 2030. According to NEMS-NRDC, ACES will drive an additional investment of $306 billion in low- or no-emissions electricity generation technologies between 2012 and 2030, which includes $103 billion redirected from conventional fossil-fuel generation. ACES will also drive $32 billion of additional investment to increase the efficiency of residential and commercial equipment.

ACES WILL CREATE CLEAN ENERGY JOBS FOR AMERICANS

Clean energy investments create more jobs across all skill and education levels than comparable investments in fossil-fuel energy sources because clean energy employs United States workers to capture domestic energy efficiency and renewable energy opportunities. The Political Economy Research Institute (PERI), an independent unit of the University of Massachusetts, found that clean energy investments create 3.2 times as many jobs as fossil fuel investments. Clean energy investments also create 5.5 times as many jobs for workers with few educational credentials or work experience, and 75 percent of these jobs provide opportunities for advancement. Consistent with this analysis, a recent study by researchers at the University of California found that between 2010 and 2020, employment would be 900,000 to 1.9 million jobs higher under ACES than without the legislation.

ACES is Affordable

ACES WILL COST AMERICAN HOUSEHOLDS LESS THAN A POSTAGE STAMP A DAY

The Congressional Budget Office (CBO), the Environmental Protection Agency (EPA), and the Department of Energy's EIA have each released assessments of how much ACES will cost American households. The CBO estimates that the average annual household cost will be $160 in 2020. The other analyses, including NEMS-NRDC, provide annual estimates through 2030, allowing for direct comparisons between them. Comparing EPA, EIA, and NEMS-NRDC results, the estimates for average annual household cost range from $52 to $92. This translates to $0.14 to $0.25 per household per day. Meanwhile, median annual income levels per household over 2012-2030 are expected to be, on average, $4,700 to $5,500 higher than 2009 levels.

ACES WILL LOWER ELECTRIC BILLS FOR AMERICAN HOUSEHOLDS

Another important finding is that electricity rates will increase only slightly (after accounting for rebates that will flow back to consumers through emission allowances allocated to their local distribution companies), while energy efficiency and behavioral responses to price changes will lower electricity consumption. The combined effect is that most households will save money on their electricity bills (an average of $6 per month over 2012–2020). On a state-by-state basis, households in almost every part of the country will see monthly savings on their electric bills under ACES relative to BAU. Although bills in four states (Minnesota, North Dakota, Nebraska, and South Dakota) are projected to be a little higher under ACES than under BAU, bills in these states are still expected to be lower than they were in 2007.

ACES Will Make America More Secure

ACES CAN REDUCE OIL IMPORTS BY 5 MILLION BARRELS PER DAY

Another benefit of ACES is that it will boost domestic oil production by capturing CO_2 from power plants and other industrial sources (known as carbon capture and storage or CCS), which can be used to enhance oil production in depleted oil fields. The Department of Energy (DOE) estimates that with ample supplies of CO_2, between 45 and 64 billion barrels of domestic oil could be economically recovered through a process called CO_2-enhanced oil recovery (CO_2-EOR). The market for CO_2-EOR, however, has been limited by available supplies of CO_2. ACES will provide sufficient incentives to encourage capture of carbon dioxide on as much as 72 gigawatts of power generation capacity, as well as from industrial sources. Under both NEMS-NRDC and MARKAL, as well as EIA and EPA analyses, the projected CO_2 supply from the electric power sector alone could meet the potential economic demand for CO_2 in the lower 48 states, which is estimated to total between 9.7 and 11.7 billion tons. NRDC worked with Advanced Resources International, a specialist in CO_2-EOR, to estimate the impact that carbon dioxide captured in the MARKAL model would have on EOR out to 2050. We estimate that 1.3 million barrels per day (MBD) of additional domestic oil production would result from CO_2-EOR in 2020 under ACES, rising to 2.6 MBD in 2030 and 4.8 MBD in 2050. With lower fuel demand and more oil produced domestically, we can import far less oil and strengthen our energy security. While the MARKAL model shows that growth in CO_2-EOR partially substitutes for other forms of domestic oil production, ACES will result in a net reduction in oil imports of 2.1 MBD by 2030 and 5.0 MBD by 2050 (vs. BAU). At today's oil prices, the cumulative value of these reduced imports through 2050 will be worth more than $2 trillion, significantly boosting the net benefit of ACES to the U.S. economy.

ACES WILL LOWER OIL PRICES AND LEAD TO LESS PRICE VOLATILITY

We estimate that the additional oil production from enhanced oil recovery under ACES would be enough to lower global oil prices. It would also leave America less vulnerable to energy price shocks.

Congress Should Act Now to Pass Comprehensive Clean Energy and Climate Protection Legislation

Passage of comprehensive clean energy and climate protection legislation, such as ACES, will help avert catastrophic climate disruption by requiring emissions reductions that will redirect our resources toward cleaner, more energy-efficient technologies. As a result, we will lead the global clean energy economy, create hundreds of thousands of quality jobs here at home, and bolster our national security. ACES is an excellent first step for helping the United States achieve economic recovery, energy security, and resource sustainability. The Senate could ensure that the United States achieves these goals more quickly and at lower cost by improving and strengthening the bill in six ways:

1. Tighten the 2020 cap from the current 17 percent below 2005 levels to 20 percent below 2005 levels.
2. Include greater provisions for energy efficiency, such as mandating that one-third of allocations to local distribution companies be used for energy efficiency.
3. Strengthen renewable energy deployment policies.
4. Strengthen transportation efficiency policies.
5. Ensure a well-regulated offsets market with strong offset quality standards.
6. Maintain effective Clean Air Act authority for complementary performance standards.

Senator John Kerry (D-MA) and Senator Barbara Boxer (D-CA) introduced the Clean Energy Jobs and American Power Act at the end of September, which incorporates many of these improvements. The Senate Environment and Public Works Committee is expected to consider and modify this bill, and the full Senate will subsequently take up comprehensive clean energy and climate legislation that combines the bill produced by the Environment Committee with provisions reported by the Energy and Natural Resources Committee and other committees.

CHAPTER 1

Understanding Our Two Energy Models

NRDC used versions of the National Energy Modeling System (NEMS-NRDC) and the Market Allocation (MARKAL) models to provide two illustrations of the impact of the American Clean Energy and Security Act (ACES) on our energy system and economy. NEMS-NRDC and MARKAL are similar in that both simulate energy markets from the "bottom-up." They differ, however, in scope and how they model choices. NEMS-NRDC is a forecasting model that uses observed historical behavior to estimate how individual market participants will act in response to changing market conditions and imposed constraints through 2030. It combines detailed energy markets with a macroeconomic model to estimate the impacts of changes in how energy is produced and used (the energy system) on the economy as a whole. In contrast, MARKAL is a long-term, cost-optimization model, which minimizes total energy system costs through 2050 while accounting for the constraints imposed by such factors as energy resource availability and carbon emission limits.

While NEMS-NRDC attempts to forecast what would happen under ACES if market participants behave in a manner that mirrors past patterns, MARKAL finds the least-cost outcome and thus provides a roadmap for attaining our emissions reduction goals at the lowest long-term cost. While the imperfections of our energy market mean that the "optimal" scenario outlined in MARKAL will likely not be achieved, its results can help us develop and advocate smart policies. For example, MARKAL shows that solar power can be a large source of cost-effective generation in the long run, which suggests that policies driving investments in solar power today can have major long-term benefits, despite the fact that these technologies are more expensive than other alternatives in the short run.

Models are Based on Slightly Different Business-as-Usual (BAU) Assumptions

In NEMS-NRDC, we use the Energy Information Administration's (EIA) March Annual Energy Outlook (AEO) 2009 published release (with some modifications to reflect the extended renewable tax credits specified in the stimulus bill) as our business-as-usual (BAU) reference case.[1] The April AEO2009 updated release included changes to reflect stimulus bill provisions, as well as an updated economic forecast (reflecting the growing recession) and updated world oil prices. Because we did not perfectly replicate the changes made between the March and April releases of the AEO2009 in developing our BAU case, there are modest differences between our BAU case and the April AEO2009 updated release with the stimulus bill. For example, our BAU case forecasts slightly higher total primary energy consumption and energy-related carbon dioxide (CO_2) emissions in 2030 relative to the AEO2009 updated release by 2.0 percent and 3.5 percent, respectively. Otherwise, NEMS-NRDC used all of the same baseline and technology cost and performance assumptions as the AEO2009 published release, except for when we explicitly changed variables in our sensitivity analysis (as discussed below).

In MARKAL, BAU is also calibrated to the March AEO2009 published release, and was modified to reflect the stimulus bill (including provisions for weatherization, the State Energy Program, the greening of General Service Administration-operated buildings, the removal of dollar caps in the investment tax credit for geothermal heat pumps and solar water heaters, and the extension of the renewable energy production tax credit), higher overnight capital costs for geothermal generation technologies, lower progress ratios for solar photovoltaic (PV) and onshore wind generation technologies, a more constrained biomass supply, and slightly lower cost assumptions for more efficient light-duty vehicles (LDVs). In this case, total primary energy and energy-related CO_2 emissions in 2030 are 2.9 percent and 3.5 percent lower, respectively, than in the April AEO2009 reference case.

Models Show Different Results for Four Main Reasons

1. Model Architecture:

- NEMS-NRDC uses historical behavior and assumes "stickiness" in markets to predict how individual market participants will behave going forward. Investment decisions are based on relatively short time horizons in an effort to reflect observed behavior.
- MARKAL has "perfect foresight" (it chooses the outcome that minimizes the total cost to society over the full time-period of the model, while adhering to limitations on the speed of change that are imposed in the model). In other words, it makes decisions based on finding the least-cost path for the entire economy through 2050.

2. Assumptions: While NEMS-NRDC and MARKAL share many of the same assumptions, there are important differences.

- NEMS-NRDC assumptions follow those presented in the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) in order to facilitate a comparison between our results and those published by the EIA.
- MARKAL also generally follows the AEO assumptions, but in a few instances, we concluded that the AEO assumptions do not best reflect the literature and we made adjustments to those selected assumptions in MARKAL. The primary changes relate to electricity generation technologies, vehicle costs, and biomass supply (see Technical Appendix for details).
- MARKAL has a less detailed representation of the energy system than NEMS-NRDC, which results in faster run times and makes MARKAL a more nimble model for the analysis of various scenarios. The NEMS-NRDC model, on the other hand, provides more granularity in its assumptions.

3. Policies Modeled:

- In both NEMS-NRDC and MARKAL, we modeled most of the major complementary policies in ACES, including the renewable electricity standard (RES), carbon capture and sequestration (CCS) deployment incentives, and energy efficiency provisions. There are, however, some differences in how these policies are represented in the two models (see Technical Appendix).

- Transportation system efficiency improvements are reflected only in MARKAL: ACES does not mandate a reduction in driving, but does provide funding for developing strategies to improve regional transportation efficiency, potentially resulting in reduced driving (often referred to as "vehicle miles traveled"). Whereas we take a conservative approach in NEMS-NRDC and do not include these impacts because they are not directly specified in ACES, our MARKAL modeling assumes that some reductions will occur.
- In both NEMS-NRDC and MARKAL, the 2007 energy bill vehicle efficiency standards are included in the BAU baseline, and we assume that these standards are extended under ACES, reaching 42 mpg in 2020 and 55 mpg in 2030. These extended standards are not fully achieved under NEMS-NRDC because the model projects that manufacturers will choose to pay fines rather than fully comply.
- In MARKAL, we incorporated estimated supply and costs of economic CO_2-enhanced oil recovery potential, establishing this as a market option for captured CO_2 that results from CCS deployment incentives in ACES.

4. Stimulus in Baseline: MARKAL's baseline was calibrated to the March 2009 AEO published release and then adjusted to reflect both the extended renewable energy tax credits and energy efficiency provisions of the stimulus bill. NEMS-NRDC just reflects the tax credits. As a result, the post-stimulus baselines for each model are slightly different, with MARKAL reflecting greater efficiency measures.

Using Two Distinct Models Instead of One Provides Greater Insight

Taking all of these elements into consideration, NEMS-NRDC and MARKAL should not be expected to have identical results. Instead, they should be viewed as representing different parts of the spectrum of possible results. NEMS-NRDC takes a more conservative approach, adopting the EIA's AEO assumptions, and only reflecting provisions clearly specified in ACES. Meanwhile, MARKAL shows what is possible from the bill if market barriers are reduced and participants take a longer-term view to making decisions than has typically been observed. Reality will likely fall somewhere between the two.

NRDC's modeling was carried out by OnLocation (for NEMS-NRDC) and International Resources Group (for MARKAL). More details on the assumptions in both models are available in the Technical Appendix at www.nrdc.org/cap2.0.

CHAPTER 2

Estimating the Cost of ACES

Trade organizations that oppose comprehensive clean energy and climate legislation claim that it will be prohibitively expensive for the economy in general and for energy consumers in particular. But the NEMS-NRDC and MARKAL models both corroborate government estimates that the costs of implementing ACES will be modest. This estimation reflects several factors, including relatively modest emission allowance prices, allowance value rebates to consumers, and cost-effective energy efficiency opportunities.

ACES Will Cost the Average Household Less Than a Postage Stamp a Day

MANY AUTHORITIES AGREE THAT THE COST OF ACES TO HOUSEHOLDS WILL BE MODEST

The Congressional Budget Office (CBO), the Environmental Protection Agency (EPA), and the Department of Energy's (DOE) Energy Information Administration (EIA) have each released their own estimates of how much ACES will cost the average household. The CBO predicts that the annual cost to the average household (measured as purchasing power) will be $160 in 2020 (with the poorest quintile seeing a net benefit of $125). The other analyses, including NEMS-NRDC, provide annual estimates through 2030, allowing for direct comparisons between them. Comparing EPA, EIA, and NEMS-NRDC results, the estimates for average annual household cost range from $52 to $92, as shown in Figure 1.[2] This translates to $0.14 to $0.25 per household per day.

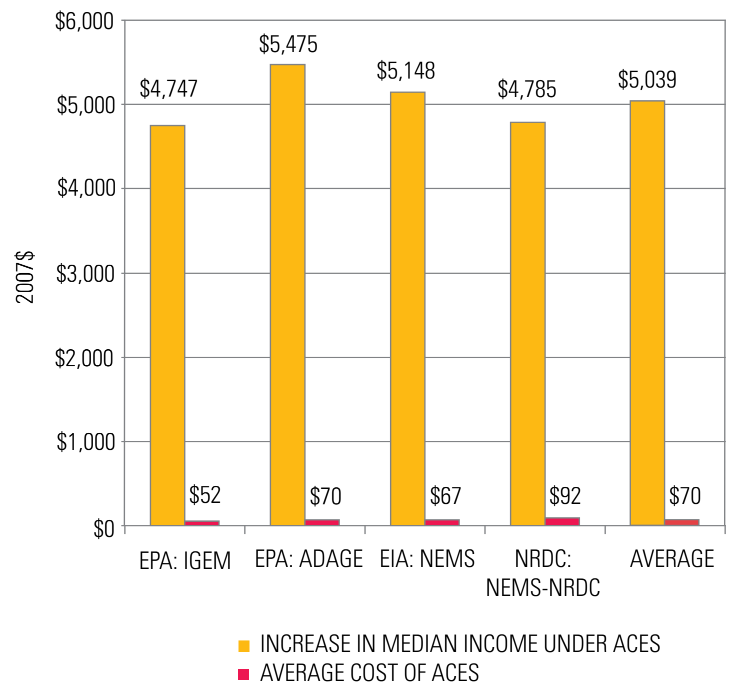
Note that we did not include in Figure 1 the $160 cost per household that the CBO predicted for 2020, since their estimate applied only to 2020, whereas the graph below shows the 2012–2030 average. If we had included it, the average would rise from $70 to $88. Also, MARKAL results are not included in Figure 1 because it is an energy system model and not a macroeconomic model, and thus comparable data is not available from it.

The CBO's estimate, while still modest, is higher than the other estimates reviewed here. This may be because the CBO focused on modeling Title III of the bill (the cap-and-trade mechanism), without fully incorporating the effects of other provisions such as energy efficiency. In contrast, we (along with the EPA and the EIA) aimed to model all major provisions of ACES, including complementary policies such as the energy efficiency provisions that result in significant cost reductions.

HOUSEHOLD INCOMES ARE EXPECTED TO RISE

Figure 1 also shows that median annual income levels per household over 2012-2030 are expected to be, on average, $4,700 to $5,500 higher than 2009 levels. To calculate income levels, we assumed that the 2007 United States median household income of $50,233 (in 2007 dollars) will grow at the same rate as consumption per household under ACES.

Figure 1. Increase in average 2012-2030 median annual income per household from 2009 levels, and average annual cost per household vs. BAU over 2012-2030.



ELECTRIC BILLS FOR THE AVERAGE HOUSEHOLD WILL DECREASE

Another key cost-indicator is what happens to household electricity bills. NEMS-NRDC predicts that electricity rates will increase slightly (after accounting for rebates that will flow back to consumers through emission allowances allocated to their local distribution companies). However, energy efficiency and demand response will lower household electricity consumption. With all these factors taken together, most households are expected to save money (an average of $6 per month over 2012–2020).

We also used regional results from NEMS-NRDC to estimate the impact on household electric bills by state. The results are encouraging: households in almost every part of the country will see monthly savings on their electric bills under ACES relative to BAU, as shown on the map below in Figure 2 (which represents the average over 2012–2020).

Although four states show negative numbers (Minnesota, North Dakota, Nebraska, and South Dakota) under ACES, their bills are still expected to be lower than in 2007. The NEMS-NRDC model forecasts that the decrease in those states would be slightly larger under BAU than under ACES; hence the negative numbers.

These calculations are based on NEMS-NRDC results, which are quite conservative in their projections of energy efficiency. More specifically, electricity demand in the residential sector is expected to drop just 5 percent relative to BAU in 2020 and 8 percent in 2030 in NEMS-NRDC. In contrast, MARKAL suggests that energy efficiency could reduce electricity consumption by nearly 12 percent in 2020 and 27 percent in 2030. The EPA projects an intermediate demand reduction of 8 percent in 2020 and 9 percent in 2030 in their ADAGE model, while McKinsey finds that the residential sector can reduce its end-use energy consumption by 28 percent relative to BAU by 2020 if it captures all positive net present value (NPV) opportunities.[3] If ACES is amended to mandate greater investments in efficiency, we believe that the household impacts would be even more favorable.[4]

Note that Figure 2 does not reflect the capital costs of more efficient equipment. For a full explanation of the methodology used to develop the map, please see the Technical Appendix.

ALLOWANCE PRICES UNDER ACES WILL BE MODEST

Emission allowance prices alone do not determine the net economic costs of a cap-and-trade policy because the value of emission allowances is returned to the economy, either directly through the allocation of allowances, or indirectly through the distribution of revenue obtained from their sale. Nevertheless, allowance prices are a frequently-used indicator of the adjustment costs related to establishing a carbon cap. The allowance prices produced by our analyses are consistent with the range of other studies (Figure 3), suggesting that allowances will cost $17-$32 per metric ton in 2020 and $28-$65 per metric ton in 2030 (all amounts expressed in 2007 dollars). Allowance prices are projected to increase at an annual average rate of 5 percent in all of the models shown here except for NEMS-NRDC and the EIA (which both use 7 percent).

Models vary significantly in their predictions for allowance prices and technology choices. Three primary factors account for these differences.

Models assume different costs for various low-carbon technologies. Current costs of technologies do not differ substantially between models because they are largely based upon today's production costs. However, assumptions about future costs can differ significantly. Because so much is unknown about the future costs of low-carbon technologies and other abatement opportunities, a wide range of outcomes is plausible. In particular, assumptions about how costs are affected by learning, competition, and economies of scale vary substantially from one model to the next.

There are also different assumptions about how firms and consumers will respond to price signals (e.g., through energy efficiency, conservation, and substitution). These responses are also hard to predict, and therefore subject to reasonable differences in opinion.

In addition to costs and individual market behavior, differences between models with respect to institutions and complementary government policies vary greatly. For example, some models build in cost penalties to reflect interstate jurisdictional conflicts, difficulties associated with getting permits, or community opposition (e.g., to nuclear power plants or new transmission lines). Some models make more optimistic assumptions than others about how effective

Figure 2. Average monthly electricity bill savings per household under ACES (relative to BAU), over 2012-2020.

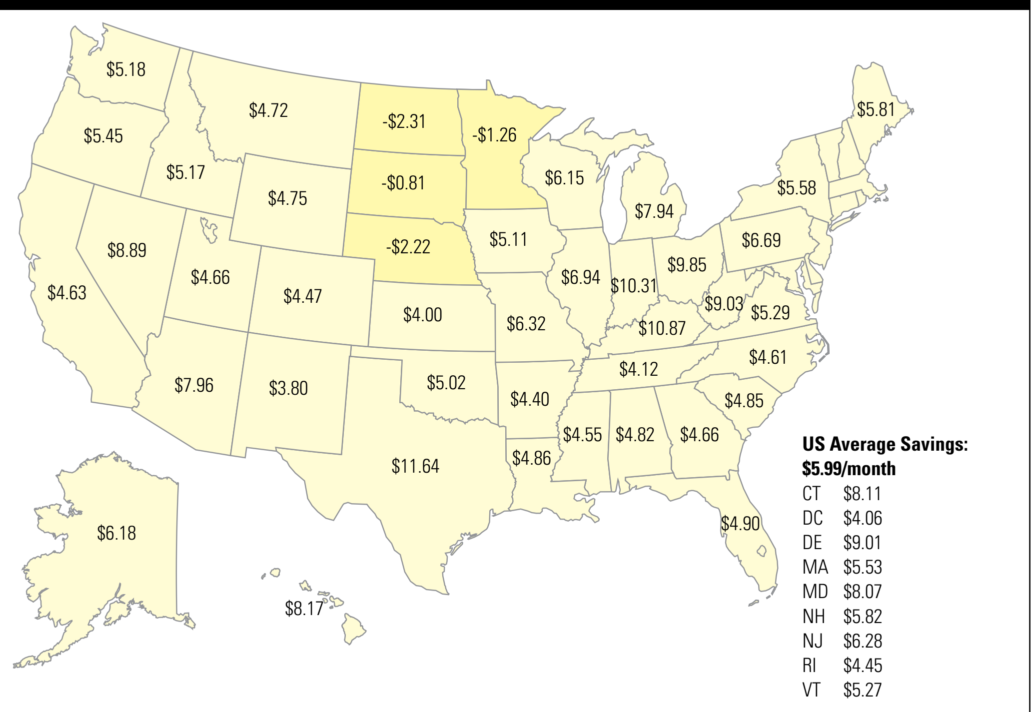
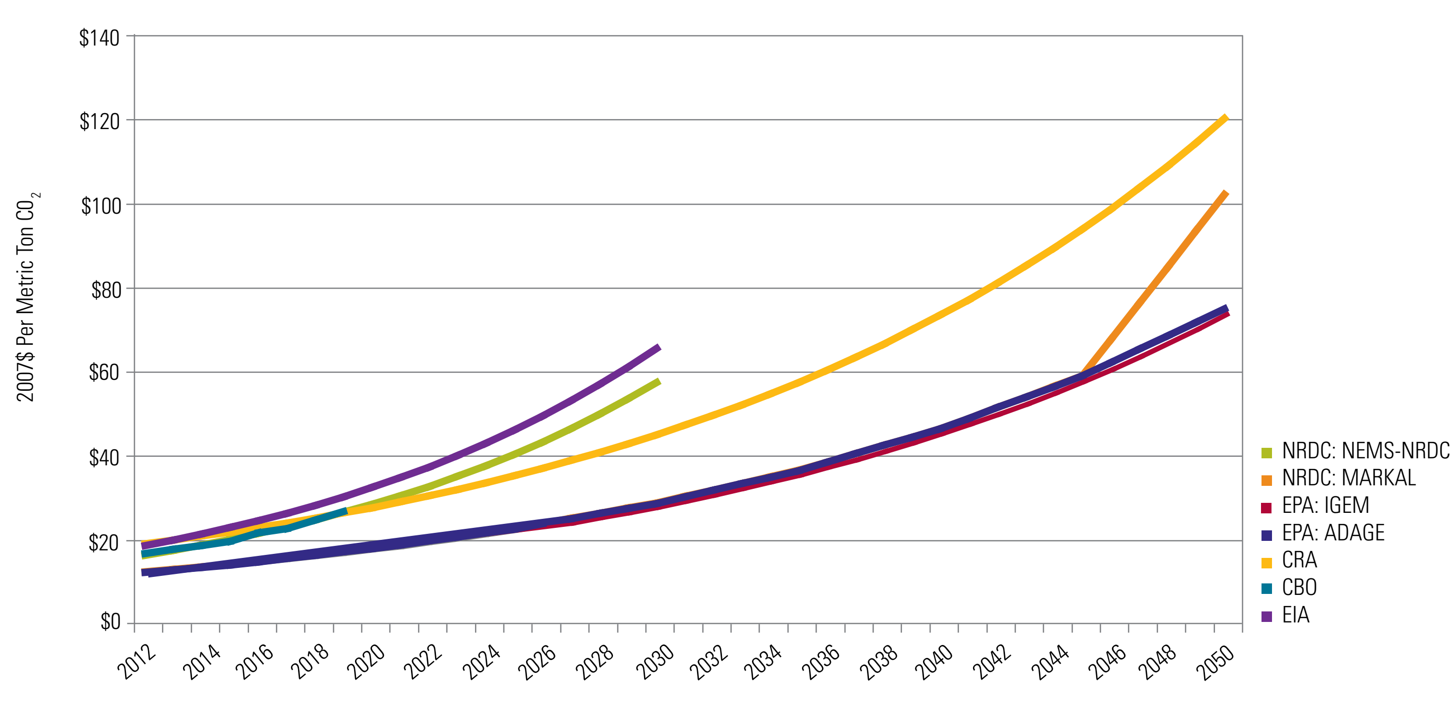


Figure 3. Allowance prices under ACES, according to NEMS-NRDC, MARKAL, EPA's IGEM and ADAGE, CRA, CBO, and EIA.



complementary policies will be (e.g., CCS subsidies), as well as different assumed efficiency standards.

Different assumptions about emission allowance banking can also significantly affect allowance price forecasts. One key assumption is how many allowances are assumed to be held in reserve (or "banked") at the end of the model time horizon. It is also important to note that in MARKAL, allowance prices rise more rapidly than the discount rate between 2045 and 2050, due to an annual limit of 150 million tons of carbon (not CO_2) placed on inter-period allowance banking. Without such a limit, the model purchases inexpensive international allowances in the 2015-2025 period and holds them until the 2045-2050 period. This amounts to assuming investors are willing to hold allowances for 30 years at a 5 percent annual return. The annual limit imposed results in a more reasonable rate of return on banked allowances, and forces the model to make investments in long-lived low-carbon infrastructure (especially power plants) toward the end of the model horizon.

MARKAL Estimates That ACES Could Lead to Approximately $1 Trillion in Total Savings Through 2050

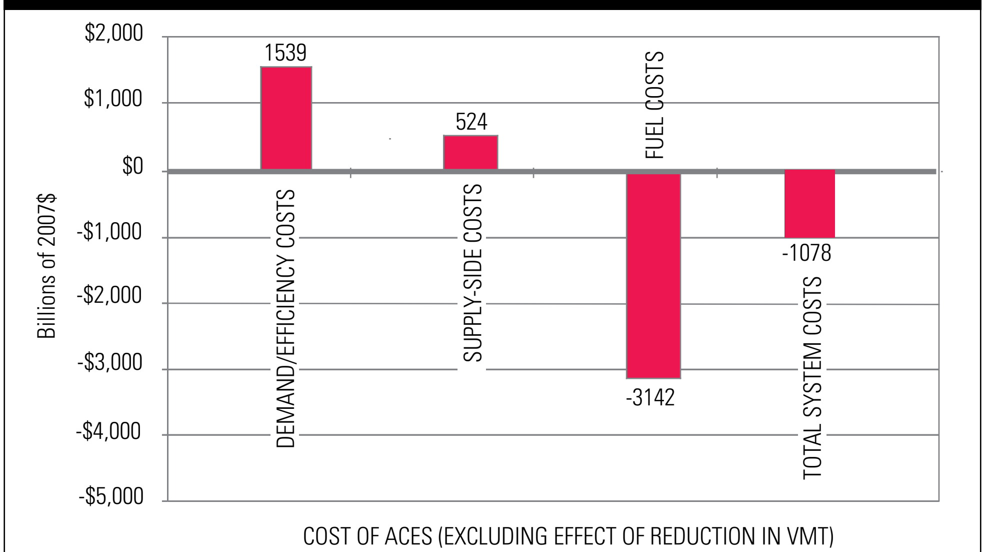
One metric that MARKAL tracks is the total cost to society, or total discounted energy system cost, which sums all energy system investment, operations and maintenance, and fuel costs over the entire model time frame, discounted at the social discount rate of 5 percent. Between 2010 and 2050, it estimates that $1 trillion could be saved relative to BAU—with increased expenditures in new, more efficient appliances and equipment and low-carbon technologies more than offset by savings from decreased expenditures on fuel and electricity. Figure 4 shows the breakdown of total system costs from 2010-2050. Please note that the effects on system costs from reduced driving (also referred to as reduction in vehicle miles travelled, or VMT) are not included in this estimate of $1 trillion because we did not attempt to quantify the costs of such a measure (due to complexities such as how much it would cost to create a large-scale shift toward transit-friendly, "smart growth" communities, the impact on housing prices, and how infrastructure costs for public transit compare to maintenance costs for highways, etc). However, it is worth noting that we would expect significant fuel cost savings from reduced driving.

As shown in Figure 4, the net savings of $1 trillion in total system costs through 2050 consists of 3 components.

- **Demand/Efficiency Costs:** These are all costs, other than fuel costs, associated with the end-use devices that use energy, including automobiles, refrigerators, light bulbs, and industrial machinery. These costs tend to go up when more expensive, more efficient devices are purchased to reduce emissions under the cap by using a smaller amount of energy to deliver the same service. On the other hand, these costs go down when there is a reduction in the service delivered, such as when consumers choose to consume less of a service because of high prices (such as turning a thermostat down).
- **Supply-Side Costs:** Investment and operating costs for supply-side devices, such as power plants and oil refineries. These costs go up when more expensive power plants are installed, but go down when load reduction reduces the need for new capacity.
- **Fuel Costs:** Expenditures on fuel for power plants and demand devices. These costs tend to go down in carbon cap scenarios because more efficient devices and more renewable power plants are used.

NEMS-NRDC projects that ACES will drive an additional investment of $306 billion in low- or no-emissions electricity generation technologies between 2012 and 2030. Of this total, $103 billion is capital redirected from conventional fossil-fuel generation toward cleaner sources of generation, while the remainder represents incremental investment in the energy sector. In addition, NEMS-NRDC forecasts that ACES will drive $32 billion of additional investment to increase the efficiency of residential and commercial equipment.

Figure 4. Total net energy system cost of ACES in MARKAL relative to BAU, presented as the discounted cost for 2012–2050, excluding the effect of a reduction in VMT.[5]



CHAPTER 3

ACES Will Accelerate Our Transition to a Clean Energy Economy

By capping global warming pollution while also investing in clean energy and energy efficiency, the cap-and-invest strategy proposed in ACES can create hundreds of thousands of jobs, stimulating the economy while protecting the environment at the same time. Our models show that a clean energy economy is within our grasp if we take action on reducing greenhouse gas emissions while investing in cleaner energy and transportation technology.

Emissions Reductions Required Under ACES Will be Met Predominantly Through Energy Efficiency, Cleaner Generation of Electricity, and Offsets

NEMS-NRDC AND MARKAL SHOW DIFFERENT ABATEMENT SOURCES

Of the total abatement relative to business-as-usual (BAU) from 2012 to 2030, NEMS-NRDC shows 31 percent coming from the electric power sector, 24 percent coming from domestic offsets, and 34 percent coming from international offsets (2012–2030 average, see left graph in Figure 5).

MARKAL shows quite a different picture, with 57 percent of abatement over that same period coming from the electric power sector and 17 percent coming from domestic offsets, as shown in the right graph of Figure 5. Extending the time frame out through 2050 results in 69 percent of abatement coming from the electric power sector and 15 percent coming from offsets (mostly domestic).

In both NEMS-NRDC and MARKAL, emission reductions from the electric power sector are due to both energy efficiency (the resulting reductions in total generation relative to BAU levels can be seen in Table 1) and cleaner generation of electricity (the share of generation from renewables, nuclear, and carbon capture and storage technologies can be seen in Table 2).

INVESTING IN EFFICIENCY AND RENEWABLES IS KEY TO LONG-RUN COST CONTAINMENT

As shown in Figure 5, domestic and international offsets serve as a major cost containment mechanism in NEMS-NRDC and account for 50 percent of economy-wide abatement in 2030. MARKAL uses many fewer offsets, while at the same time projecting lower allowance prices than NEMS-NRDC. The differences between the two sets of results are due, in part, to greater abatement in the transportation sector in MARKAL as discussed in Chapter 1. A larger driver of the differences, however, is the foresight in MARKAL, which results in greater and more rapid investments in energy efficiency and clean technologies because these investments reduce long-run system costs more than relying heavily on offsets. For example, many energy efficiency investments have a negative cost over the long term once fuel cost savings are taken into account, and early investments in renewable energy technologies reduce their long-run costs through learning. As a result, the largest source of abatement in MARKAL in 2030 comes from demand reductions and a shift in the electric power sector away from dirty fuels towards a mix of clean energy sources. Less reliance on offsets in general reduces attendant environmental risks related to the challenge of ensuring that offset credits are only issued for emission reductions that are truly additional and permanent. Less reliance on international offsets also means sending less money abroad, investing instead in our domestic economy.

An important implication of the choices observed in MARKAL is that to minimize the long-term societal costs of meeting our emissions reduction targets, we should begin the transition from a fossil-fuel economy to a clean, energy-efficient economy as soon as possible. To do so, we need to accelerate deployment of efficiency and renewables and immediately begin transforming key sectors such as power and transportation. Rather than relying heavily on cheap and potentially uncertain offsets for cost-containment, this strategy would reduce compliance costs by

Figure 5. Emissions reductions under ACES relative to BAU in NEMS-NRDC and MARKAL.

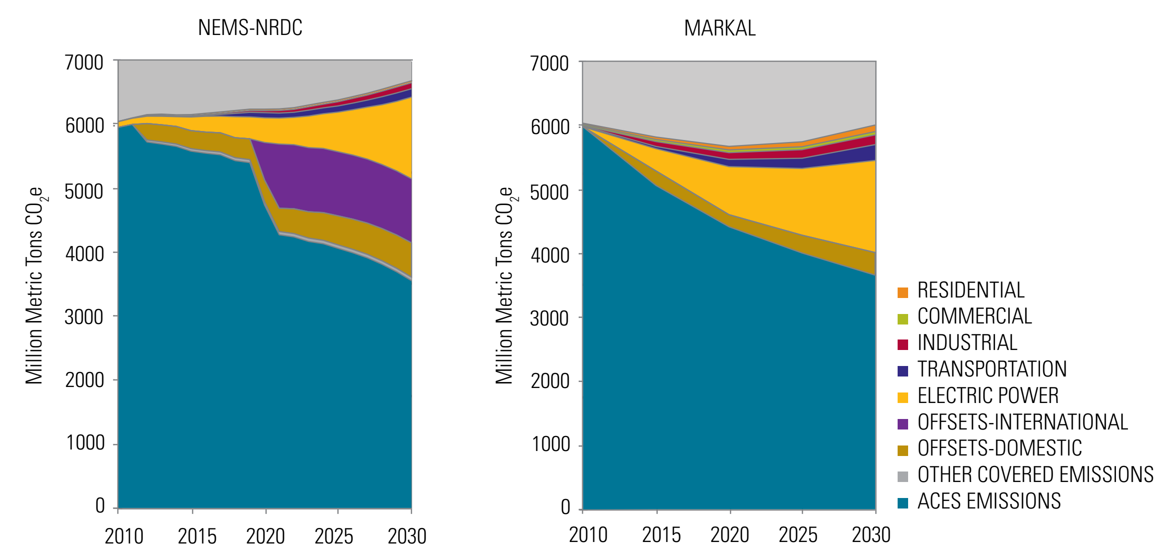


Table 1. The impact of energy efficiency: Reductions in total electricity generation vs. BAU in NEMS-NRDC and MARKAL.

	2020	2030	2040	2050
NEMS-NRDC	4%	7%		
MARKAL	12%	18%	26%	27%

Table 2. The shift toward cleaner generation: Low- or no-emissions generation (renewables, nuclear, and coal with carbon capture and storage) as a share of total generation in NEMS-NRDC and MARKAL.

	2020	2030	2040	2050
NEMS-NRDC				
BAU	32%	31%		
ACES	40%	59%		
MARKAL				
BAU	31%	29%	20%	13%
ACES	46%	60%	86%	84%

overcoming barriers that slow implementation of cost-effective energy efficiency measures and by accelerating experience-driven reductions in the cost of clean electricity generating technologies. Together with a cap on greenhouse gas emissions, this will ensure that we meet our climate protection and energy independence objectives at the lowest cost, delivering jobs, security, and a healthier environment.

ENERGY EFFICIENCY WILL SLOW OR DECREASE ENERGY USE UNDER ACES, WHILE RENEWABLES WILL EXPAND

Under BAU, economy-wide energy consumption is expected to increase 13 percent between 2010 and 2030 and 20 percent between 2010 and 2050. In contrast, NEMS-NRDC estimates that ACES will cut consumption growth in half, to 7 percent, over that same period from 2010 to 2030. Meanwhile, MARKAL results show efficiency improvements in the vehicle fleets and in residential and commercial buildings decreasing primary energy use 8 percent from 2010 to 2030 and 3 percent from 2010 to 2050—while meeting the overall demand for energy services.

Figure 6 demonstrates the overall energy consumption patterns in each model. Both models show renewables taking market share from coal, natural gas, and oil, but that trend is more pronounced in MARKAL for the following reasons: (1) NEMS-NRDC and MARKAL both include a technology learning function such that deployment of renewables and other advanced technologies such as coal with carbon capture and sequestration (CCS) will drive their investment costs down. However, MARKAL's perfect foresight allows it to see the future benefit of making such investments earlier, which makes them more economically attractive compared to the offsets that NEMS-NRDC uses more heavily. As a result, it chooses to make a greater investment in renewables than NEMS-NRDC; (2) nuclear is a smaller part of the solution in MARKAL, which leaves more room for the other technologies; and (3) NEMS-NRDC imposes additional constraints on interregional power flow and does not have a concentrating solar power (CSP) option with energy storage, thus limiting the role of this solar technology considerably.

LARGE FUEL-SWITCHING SHIFTS FROM COAL TO NATURAL GAS ARE NOT EXPECTED

Both NEMS-NRDC and MARKAL project somewhat lower demand for natural gas under ACES than under BAU. This is a consequence of two competing effects: natural gas has the lowest carbon content (per unit of energy) of the fossil fuels, giving it an economic advantage over coal in power plants that don't capture their carbon dioxide as allowance prices rise. On the other hand, emissions from natural gas combustion are still significant, which favors energy efficiency and low- and no-emission generating technologies over all fossil fuels, including gas. Given the relative price of coal and gas and the allowance prices in our models, we do not see large scale fuel switching in the near-term, while in the longer term renewables and CCS take market share from both conventional gas and coal. (According to the EIA, recent increases in natural gas reserves based on new technology to produce shale gas have been accounted for in the AEO2009 natural gas supply assumptions that were then incorporated into NEMS-NRDC. This is reflected in moderate and relatively stable gas prices, which range between $6.32 in 2014 and $7.90 in 2030 at Henry Hub).

Under ACES, the Electric Power Sector Will Migrate Away From Conventional Fossil Fuel Technologies Toward Renewables and Carbon Capture and Storage Generation

Both models project that the power sector will reduce emissions through two main factors: (1) shifting to lower-carbon generation and (2) reduced demand through end-use energy efficiency and demand response (which is behavioral responses to changes in prices). NEMS-NRDC projects slight decreases in electricity generation from coal and gas through 2030 and a corresponding shift toward renewables and nuclear.[6] MARKAL projects a more pronounced reduction in conventional fossil-fuel generation, as seen in Figure 7.

In addition to increases in renewables, both models project increases in fossil generation equipped with CCS. NEMS-NRDC projects that CCS comes online in 2016; MARKAL projects that CCS comes online in 2015. Boosted by CCS deployment incentives in ACES, coal with CCS is expected to account for 94 billion kWh (or 2 percent) of generation in 2020 and 682 billion kWh (or 15 percent) in 2030 under NEMS-NRDC. MARKAL estimates that coal with CCS will account for 126 billion kWh (or 3 percent) in 2020, 297 billion kWh (or 7 percent) in 2030, and 1493 billion kWh (or 30 percent) in 2050, with 100 percent of coal generation equipped with CCS

Figure 6. U.S. primary energy consumption under BAU and the ACES core runs of NEMS-NRDC and MARKAL.

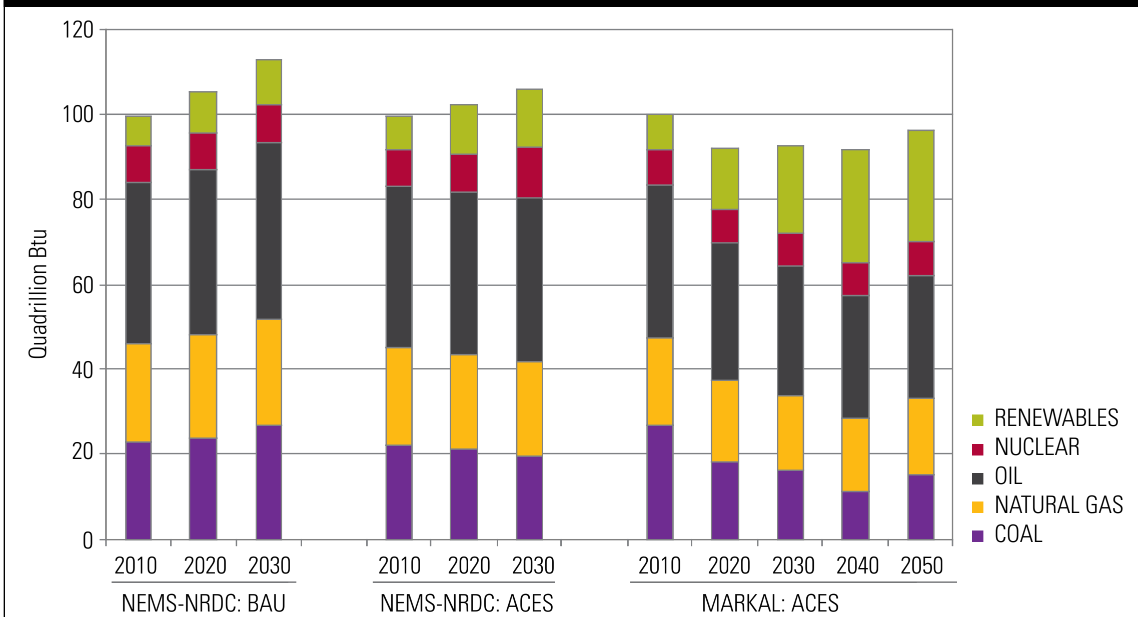


Figure 7. U.S. electric power sector generation under BAU and the ACES core runs of NEMS-NRDC and MARKAL.

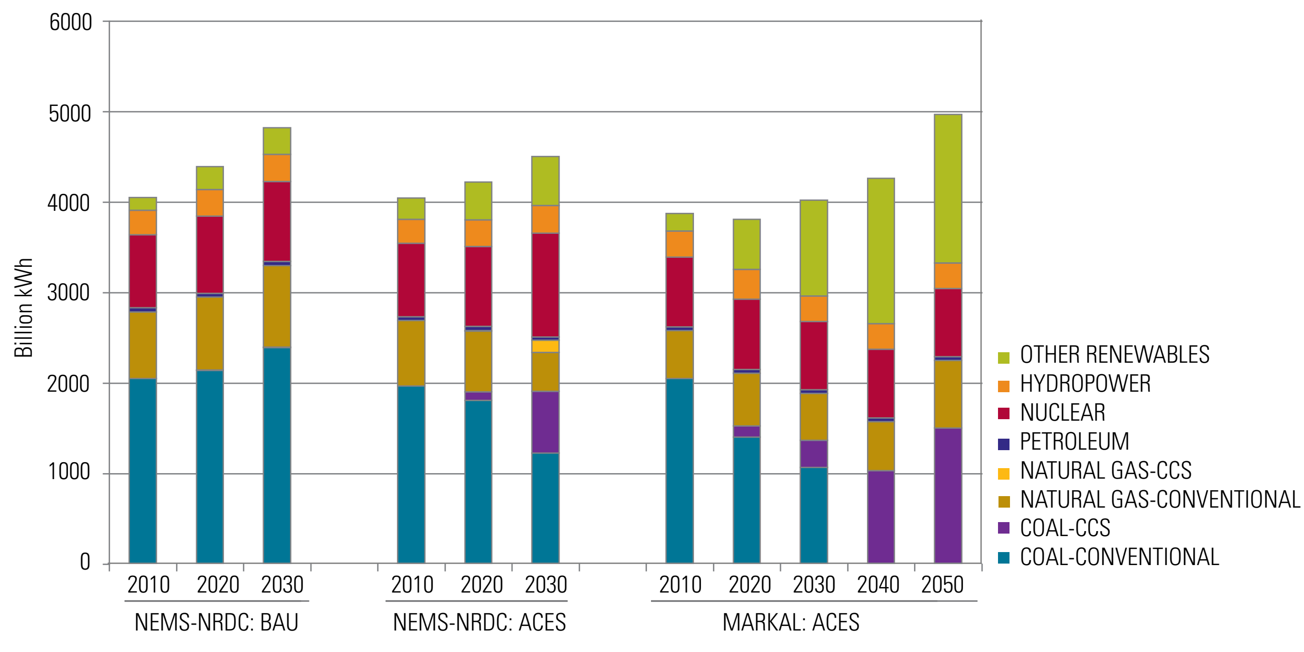
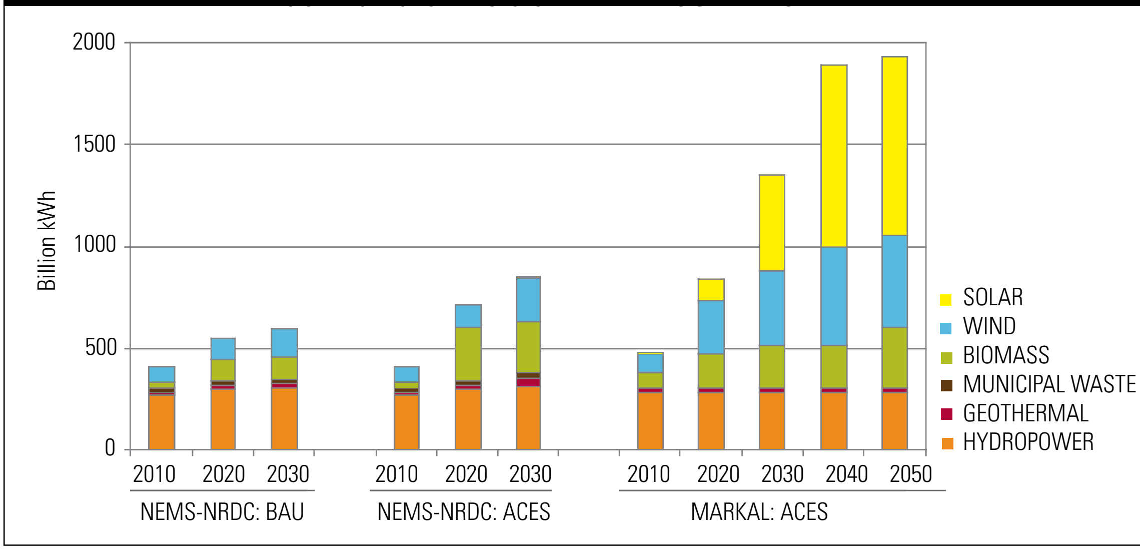


Figure 8. U.S. electric power sector renewables generation under BAU and the ACES core runs of NEMS-NRDC and MARKAL.



technology by 2045. The surge in coal with CCS accounts for the increase in fossil fuel consumption after 2040 in the MARKAL ACES scenario.

Meanwhile, a small amount of natural gas with CCS comes online in 2020 in NEMS-NRDC, accounting for 7 billion kWh, which grows to 129 billion kWh by 2030 under NEMS-NRDC.

Figure 8 provides a breakdown of renewable electricity generation. Interestingly, NEMS-NRDC projects little incremental increase in wind relative to BAU, and almost no solar. The fact that NEMS-NRDC projects little solar generation is in large part due to the lack of an option with storage capability in addition to the lack of perfect foresight in NEMS-NRDC. Instead, most of the incremental renewables generation comes from biomass, particularly biomass co-fired with coal in the early years of the forecast, giving way to more dedicated biomass by 2030. In contrast, MARKAL shows a surge in wind, solar, and biomass, with particularly rapid growth in solar starting around 2030 (predominantly concentrating solar power, or CSP). In MARKAL, part of the reason solar achieves a larger market share than wind is that CSP with integrated thermal storage provides more valuable peak power. In contrast, the model assumes that all wind resources peak at night, when power is less valuable.

We suspect that if NEMS-NRDC included the option of building storage capability for its solar technologies (as MARKAL does), solar would have been a larger part of the solution. The NEMS-NRDC and MARKAL results illustrate the importance of policies to spur the development and deployment of energy storage technologies, such as molten salt storage.

The noticeable difference in the amount of renewable electricity generation between NEMS-NRDC and MARKAL suggests that policies that accelerate the deployment of renewables generation (e.g., through a stronger renewable energy standard) would help promote a faster transition to clean technologies. Furthermore, assuming that we continue to see cost reductions with greater capacity build-out, that will result in reduced societal costs over the long term. Such policies would reduce the cost of emerging technologies, especially those with steep learning curves, and could provide significant long-term economic benefits by providing a broader set of options to meet ambitious longer-term abatement targets.

However, the renewable electricity standards (RES) in ACES would need to be strengthened and complemented with incentives for emerging renewables in order to achieve accelerated deployment and cost reductions for multiple technologies. The RES in ACES is likely to be non-binding, since up to 40 percent of it can be met through energy efficiency. In 2020, that means that the stated RES of 20 percent can be as little as 12 percent, which NEMS-NRDC shows will happen even under BAU.

ACES Can Lead to Increased Domestic Oil Production and Increased Transportation Efficiency, Improving Our Energy Security and Reducing Our Exposure to Fossil Fuel Price Volatility

With the build-out of power plants equipped with CCS, as predicted in both NEMS-NRDC and MARKAL (see Figure 7), ACES will boost domestic oil production by capturing CO_2 from power plants and other industrial sources, which can be used to enhance oil production in depleted oil fields.

The Department of Energy (DOE) estimates that over 60 percent of the oil discovered in the United States is considered “stranded” and uneconomical to recover conventionally. CO_2-enhanced oil recovery (CO_2-EOR) can yield up to 20 percent more of the original oil in place, extending the productive life of existing oil fields by 20 to 30 years. Oil field operators in western Texas, Mississippi, and Wyoming have been using this method for more than 30 years; they are currently producing more than 250 thousand barrels of oil per day. The DOE estimates that with ample supplies of CO_2, between 45 and 64 billion barrels of domestic oil could be economically recovered.

The market for CO_2-EOR, however, has been limited by available supplies of CO_2. ACES will provide sufficient incentives to encourage capture of carbon dioxide on as much as 72 gigawatts of power generation capacity, as well as from industrial sources. Under both NEMS-NRDC and MARKAL, as well as EIA and EPA analyses, the CO_2 supply from the electric power sector alone is projected to meet the potential economic demand for CO_2 in the lower 48 states, which is estimated to total between 9.7 and 11.7 billion tons.[7] The amount of CO_2 that various analyses expect to be captured from electricity generation technologies with CCS is shown in Table 3.

NRDC worked with Advanced Resources International, a specialist in CO_2-EOR, to develop CO_2-EOR oil supply and cost estimates, which we integrated into the MARKAL model to assess the impact that carbon dioxide captured in the electric sector would have on EOR out to 2050. We estimate that 1.3 million barrels per day (MBD) of additional domestic oil production would result from CO_2-EOR in 2020 under ACES, rising to 2.6 MBD in 2030 and 4.8 MBD in 2050.

With lower fuel demand and more oil produced domestically, we can import far less oil and strengthen our energy security. While the MARKAL model shows that growth in CO_2-EOR partially substitutes for other forms of domestic oil production, ACES will result in a net reduction in oil imports of 2.1 MBD by 2030 and 5.0 MBD by 2050 (vs. BAU), with the United States eventually importing just 27 percent of the oil it needs (see Figure 9), down from importing more than 60 percent of our oil needs today. At today's oil prices, the cumulative value of these reduced imports through 2050 will be worth more than $2 trillion, significantly boosting the net benefit of ACES to the U.S. economy.

The additional oil production from enhanced oil recovery under ACES would be significant enough to meaningfully lower global oil prices and leave America less vulnerable to energy price shocks.

Figure 9. Domestic and imported breakdown of crude oil and refined products consumption from 2010 to 2050, under MARKAL.

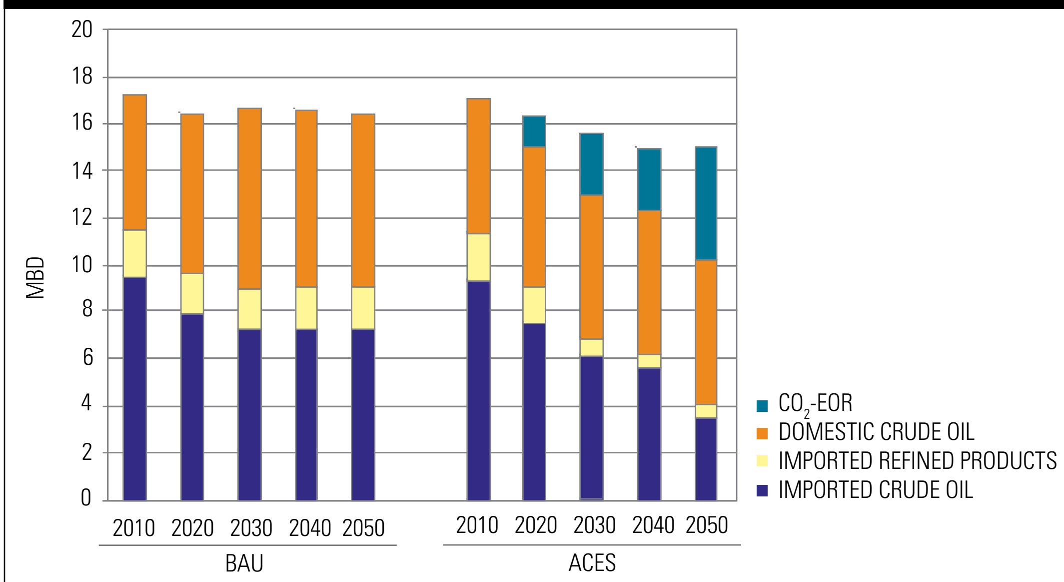
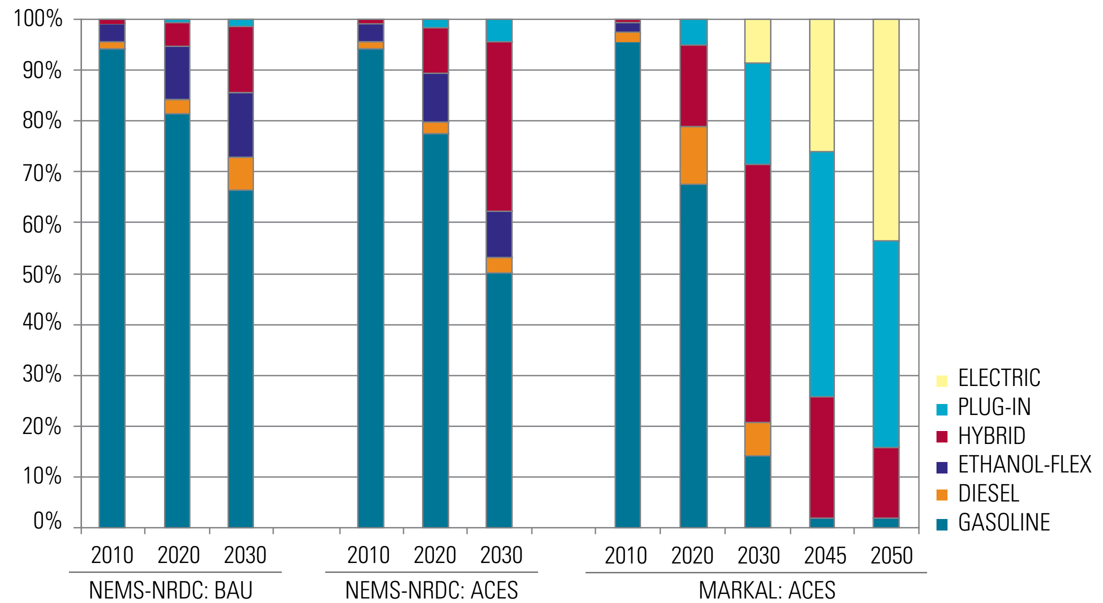


Table 3. Carbon dioxide captured from electricity generation technologies with CCS in 2020 and 2030 (MILLION METRIC TONS CO_2).

	EPA: IGEM	EPA: ADAGE	EIA: NEMS	NRDC: NEMS-NRDC	NRDC: MARKAL
2020	152	152	85	76	124
2030	207	230	409	538	243

Figure 10. Light-duty on-road fleet mix, according to share of vehicle miles traveled per technology type, under BAU and the ACES core runs of NEMS-NRDC and MARKAL.



ACES Will Promote the Adoption of Nontraditional Light-Duty Vehicle (LDV) Technologies and Reduce Fuel Consumption

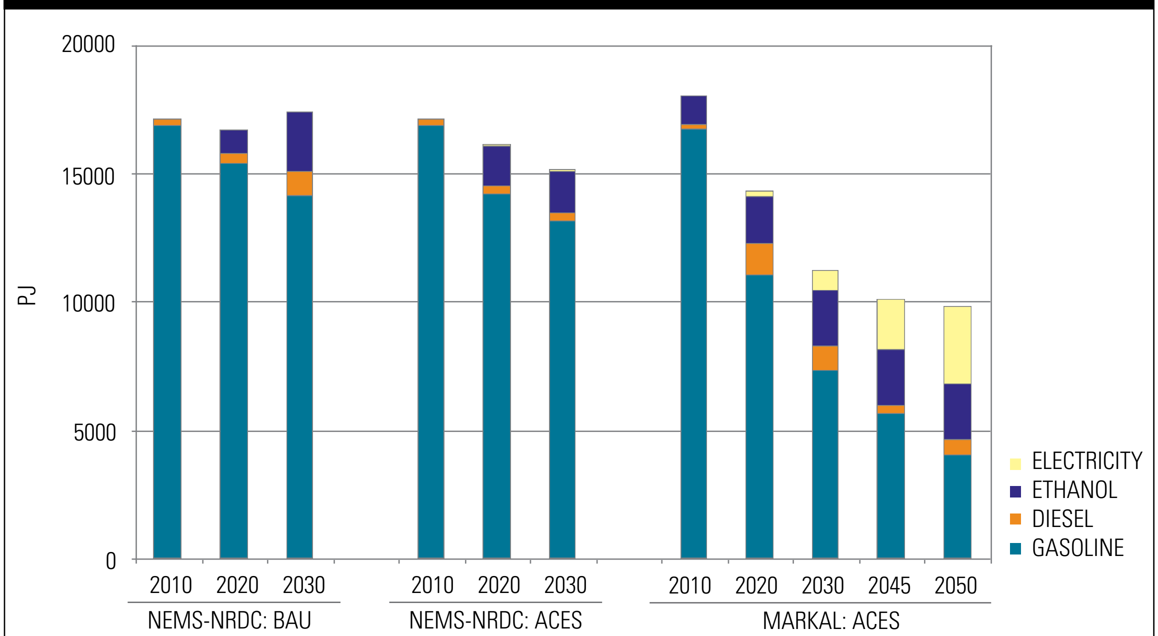
Figure 10 shows that under BAU in NEMS-NRDC, the light-duty vehicle (LDV) mix is projected to be 73 percent gasoline or diesel technologies in 2030, but ACES would cause that share to drop in NEMS-NRDC to 53 percent. Although NEMS-NRDC and MARKAL both project a large role for hybrids (with 33 percent of 2030 market share in NEMS-NRDC and 50 percent in MARKAL), MARKAL also projects that plug-ins and electric vehicles will displace gasoline vehicles. Two possible explanations for this dramatic difference are: (1) MARKAL assumes that fuel-efficiency technologies will be adopted as long as it results in cost savings over its lifetime (assumed to be 15 years), and NEMS-NRDC requires a three-year payback. As a result, the requirement NEMS-NRDC sets for fuel-efficient technologies is much higher than in MARKAL; (2) NEMS-NRDC uses AEO2009 reference case assumptions for the cost of more efficient vehicles, while MARKAL uses AEO2009 high technology case assumptions, which are slightly lower than those in the reference case, and more in-line with estimates from the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA).

Near-term increases in the corporate average fuel economy (CAFE) standards pursuant to the 2007 energy bill (EISA) are included in BAU (reaching 35 mpg by 2020). However, we assumed higher efficiency standards in the ACES runs for both NEMS-NRDC and MARKAL because: (1) The national program for passenger vehicle efficiency announced by President Obama in May 2009 moves up the schedule for reaching 35 mpg to 2016 instead of 2020 and (2) ACES has incentives to promote continued improvements in vehicle efficiency. ACES adds $25 billion to the EISA efficient vehicle manufacturer loan guarantees and also allocates another $28 billion in allowance value for automaker clean vehicle technology programs. These investments in clean, efficient vehicles pave the way for higher standards beyond those currently included in the base case, even though such higher standards are not explicitly required in ACES. In both models, we assumed vehicle efficiency standards of 42 mpg in 2020 and 55 mpg in 2030. In MARKAL, we assumed continued improvements to 80 mpg in 2050. It is important to note, however, that these standards are not fully achieved in NEMS-NRDC. Given the vehicle cost and performance assumptions in that model, NEMS-NRDC finds that it would be cheaper for vehicle manufacturers to pay non-compliance fines than fully meet the standard. As a result, vehicle efficiency reaches 40 mpg in 2020 and 48 mpg in 2030 in NEMS-NRDC, whereas MARKAL assumes that the specified standards will be achieved.

While both NEMS-NRDC and MARKAL estimate some changes in the fuel mix, as seen in Figure 11, the more significant difference between the two scenarios is the amount of fuel consumed. The total fuel consumption is 12 percent less under ACES than BAU in 2030 in NEMS-NRDC and approximately 27 percent less in MARKAL. This reduction in fuel consumption in both models is due to a combination of factors: more efficient vehicles (due to individual technologies becoming more efficient, and also a shift toward different drive trains, such as plug-ins), transit mode shifts (only in MARKAL), and demand response.

MARKAL assumes that transportation system policies will reduce vehicle miles traveled (VMT) by 5 percent in 2020, 9 percent in 2030, and 12 percent in 2050 relative to BAU. Of this reduction in VMT, we assume that 15 percent will shift to public transit (the shift is split 55 percent rail and 45 percent bus), with the remaining 85 percent representing a net reduction in VMT overall. Those assumed VMT reductions are similar in magnitude to what can be achieved through smart growth and land use planning strategies, as evaluated in the July 2009 Moving Cooler report.[8] That report estimates that smart growth could result in a 6–10 percent reduction in national light-duty VMT by 2030. But as mentioned previously, ACES supports smart growth planning but does not explicitly mandate reductions in VMT.

Figure 11. Fuel consumption of light-duty vehicles under BAU and the ACES core runs of NEMS-NRDC and MARKAL.



CHAPTER 4

Considering the Impact of Alternative Assumptions

The results of any forecasting model depend on the assumptions that drive it, and some of these assumptions are inherently uncertain. Models can nonetheless provide important insights, particularly by examining how their results vary in response to changes in key input assumptions. In this section we examine the sensitivity of our results to assumptions about complementary policies, the 2020 target, offset supply, technology costs, and transportation policies.

Complementary Policies Significantly Lower Compliance Costs

We performed a run in both the NEMS-NRDC and MARKAL models in which just the cap was imposed by itself, without complementary policies that mandate or provide incentives for energy efficiency, renewables, CCS, transportation mode shifts, vehicle efficiency, etc. The results showed allowance prices 10 percent higher in NEMS-NRDC and 69 percent higher in MARKAL. Furthermore, MARKAL showed that implementing a cap alone would cost society $1.5 trillion more from 2012 to 2050 than ACES (including investment, operations and maintenance, and fuel costs). MARKAL shows a more significant increase in allowance prices under a cap alone because the complementary policies that differentiate the "ACES" case and the "Cap alone" case are more aggressive than those in NEMS-NRDC. For example, as mentioned previously, it reflects reductions in driving miles due to better transit, while NEMS-NRDC does not.

Raising the Emissions Reductions Target for 2020 Would Not Have a Major Impact on Costs

The Kerry-Boxer bill introduced in the Senate at the end of September sets the 2020 emissions target at 20 percent below 2005 levels, rather than 17 percent below 2005 levels, as in the version of ACES that passed the House of Representatives. In both NEMS-NRDC and MARKAL, we conducted a run in which we changed the 2020 target to 20 percent below 2005 levels (and left all other targets unchanged). In NEMS-NRDC, the main impacts were that allowance prices increase 6 percent and almost all of the additional required abatement comes from purchasing more offsets. In MARKAL, allowance prices also increase 6 percent when the 2020 target is raised from 17 percent to 20 percent, but the additional abatement requirement is met mostly through a slight shift in the generation mix from coal to natural gas, rather than through additional use of offsets.

The Availability of International Carbon Offsets Will Affect Allowance Prices and Progress Toward a Clean Energy Economy

In our core NEMS-NRDC run of ACES, we assumed that international projects in avoided deforestation and forest management would not generate international offsets until 2020. We imposed that constraint to reflect a conservative view about the amount of time that developing countries will need before being able to produce and sell tradable offsets in those categories that meet the standards of the United States' offsets program. As a result, the only international forestry offsets assumed to be available for purchase in the United States from 2012 to 2019 are those based on afforestation (though other types of offsets based on reducing direct emissions remain available). From 2020 onward, all three categories of international forestry-based offsets are assumed to be available on the market (afforestation, avoided deforestation, and forest management). For this sensitivity case we made two changes to international offsets supply: (1) We assumed that all offset categories would be available beginning in 2012 based on the EPA's supply curve; and (2) We raised the international limit to 1.5 billion tons from 1 billion tons since ACES provides that international offsets can be purchased up to 1.5 billion tons if domestic offset supply is insufficient to meet the domestic 1-billion-ton limit. When we make those two changes, allowance prices drop 19 percent. Sensitivity analysis conducted by the EPA indicates that increasing the international offset limit to 1.5 billion tons accounts for the largest portion of this effect (although the EPA used a different model, our offset supply curves are based on the EPA's, so we expect that the relative effects would be similar). The EPA found that if no international offsets were allowed for the first 10 years in their model, allowance prices increased by just 3 percent. In another run, the EPA placed a firm limit on international offsets of 1 billion tons and allowance prices increased 11 percent compared to their core case in which up to 1.5 billion tons were allowed.

In addition to allowance prices decreasing 19 percent in this sensitivity case, the electric power sector retires fewer conventional coal plants, and renewables and nuclear make up a smaller share of the generation mix (Figure 12). So in effect, a greater supply of offsets delays the transition to a clean energy economy, even though that transition would allow domestic emitters to reduce their emissions permanently instead of annually needing to purchase allowances or offsets.

The Role of Nuclear Power Depends on Its Cost and on the Supply of International Offsets

In NEMS-NRDC, the nuclear overnight capital cost is $3,375 per kW for a plant coming online in 2016 (in 2007 dollars). At that cost, nuclear generation increases from 806 billion kWh in 2007 to 882 billion kWh in 2020 and 1145 billion kWh in 2030—and capacity increases from 101 GW in 2007 to 111 GW in 2020 and 144 GW in 2030. We performed a run in which we doubled the overnight capital cost (consistent with recent international experience), and in that case nuclear generation increases only to 840 billion kWh in 2020, but then drops to 817 billion kWh in 2030. Meanwhile, capacity increases to 105 GW in 2020 and then down to 101 GW in 2030 (Figure 13). In this sensitivity case, allowance prices are 3 percent higher than in our core case, and generation using natural gas, coal with CCS, and renewables each increase modestly.

In contrast, the core run of ACES in MARKAL started with the same overnight capital cost per kW. In the core run, nuclear generation remains at its 2005 level of 774 billion kWh through 2025 and then decreases to 745 billion kWh in 2030 and 60 billion kWh in 2050. At the same time, capacity remains flat at the 2005 level of 104 GW through 2020 before dropping to 100 GW in 2030 and 8 GW in 2050. The decline in 2030 and thereafter reflects the fact that nuclear plants are expected to have a 60-year lifetime and thus the decision to repower vs. retire does not confront the existing fleet until approximately 2030. In the core run of MARKAL, the model is choosing to retire plants that are coming to the end of their lifetime. In an effort to understand at what overnight capital cost nuclear would become a larger part of the generation mix, we lowered the capital cost gradually until the model added between 50 GW and 100 GW of new capacity. When we lowered the cost by 15 percent,

Figure 12. U.S. electric power sector generation in NEMS-NRDC, under both the ACES core run and a sensitivity in which the international offsets limit is raised from 1.0 billion to 1.5 billion tons, and the EPA international supply curves are used (which do not constrain supply through 2020, as we do in the ACES core run).

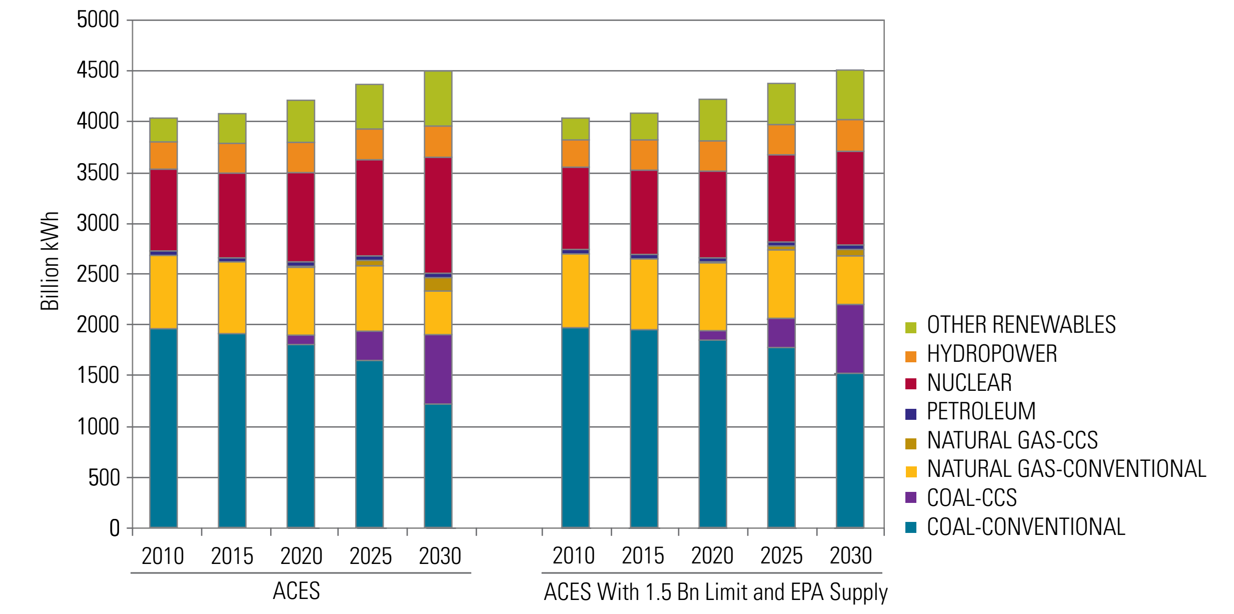


Figure 13. U.S. electric power sector generation in NEMS-NRDC, under both the ACES core run and a sensitivity in which nuclear overnight capital costs were doubled.

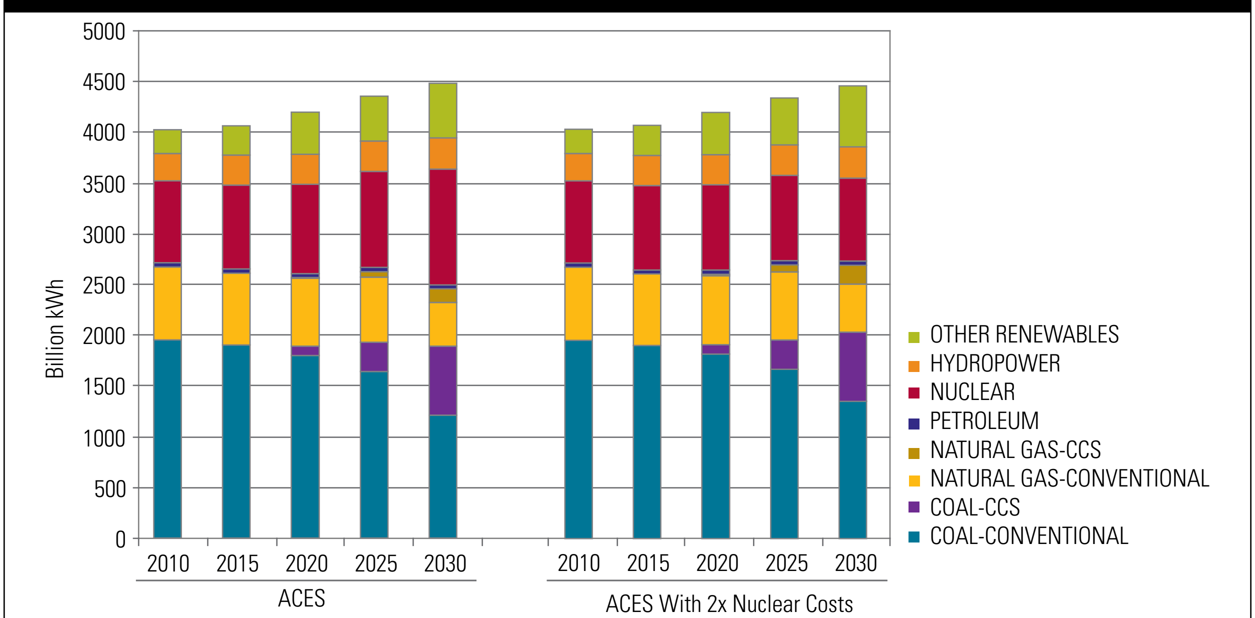


Figure 14. U.S. electric power sector generation in MARKAL, under both the ACES core run and a sensitivity in which nuclear overnight capital costs are lowered 15 percent from the levels used in the ACES core run.

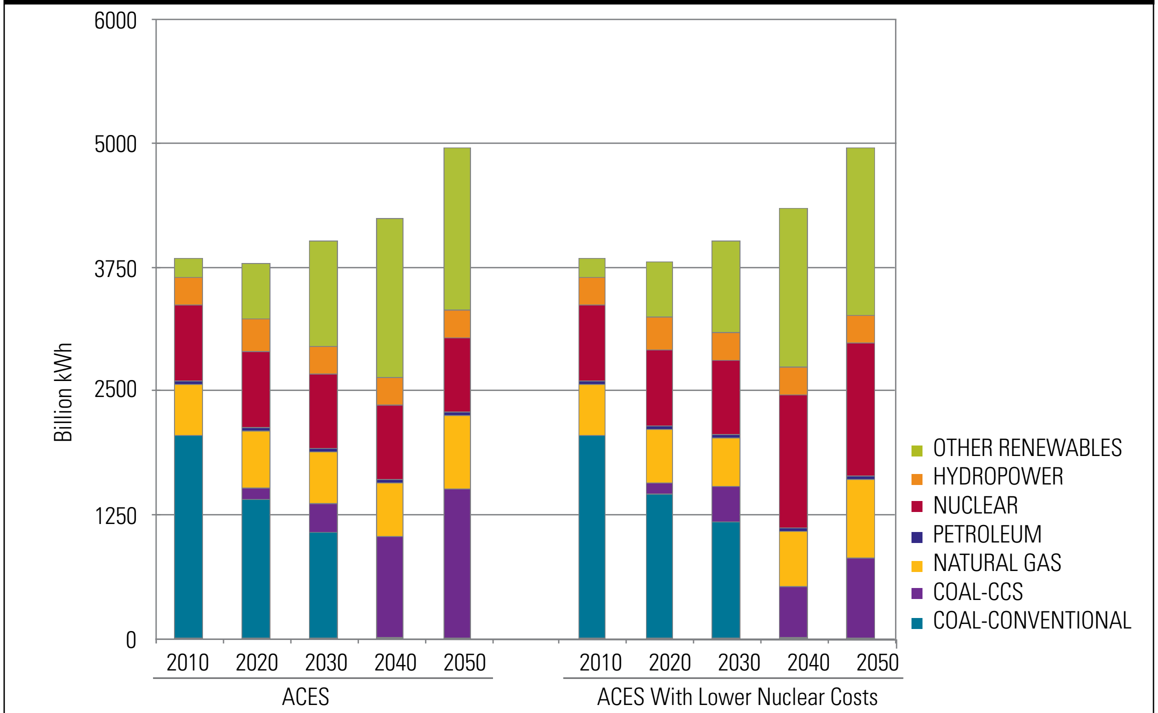


Figure 15. U.S. electric power sector generation in MARKAL, under both the ACES core run and a sensitivity in which we decreased the nuclear plant lifetime from 60 years to 50 years.

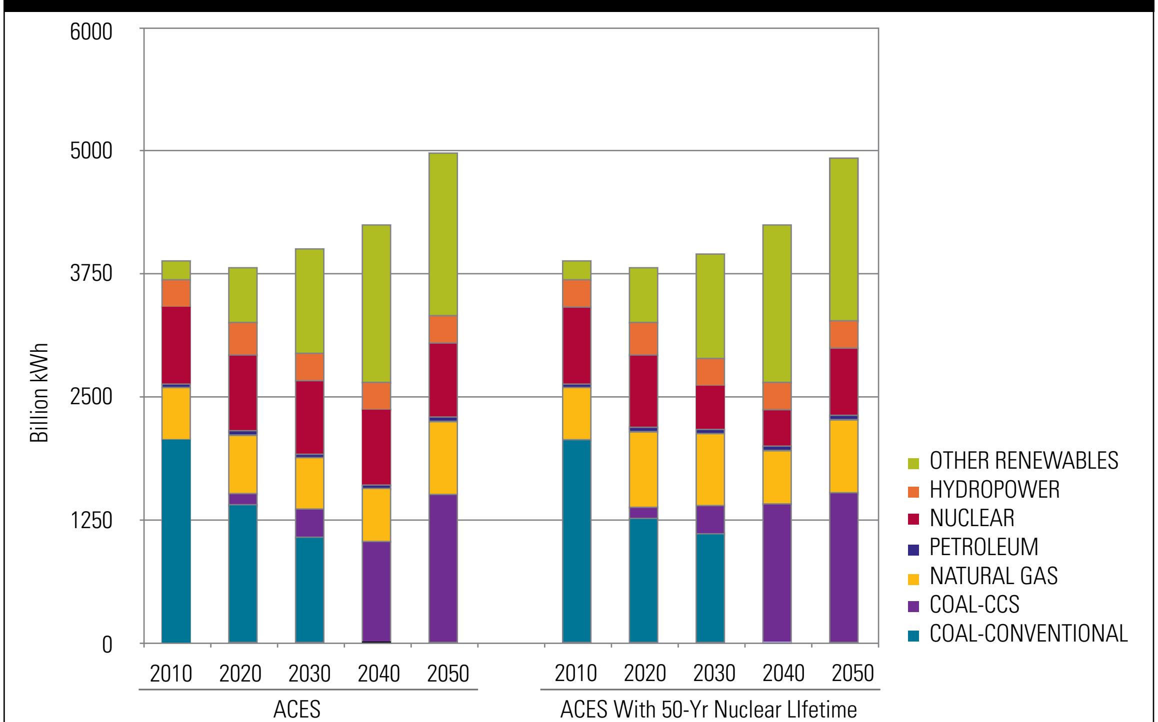
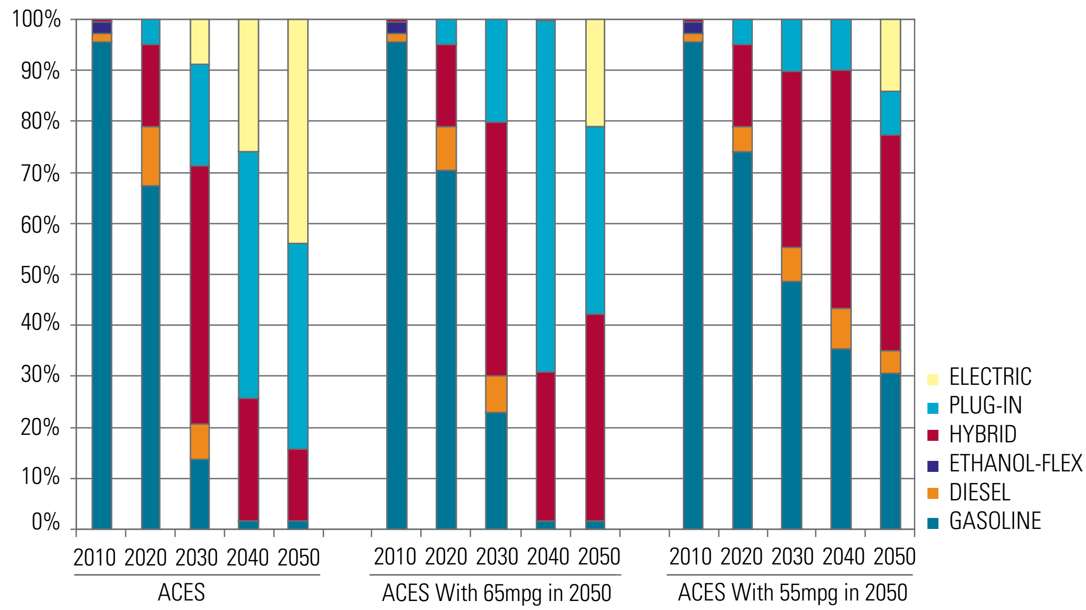


Figure 16. Share of vehicle miles traveled per technology type in MARKAL, under the ACES core run, a sensitivity in which the CAFE standard in 2050 is lowered from the 80 mpg in the core run to 65 mpg, and another sensitivity with a CAFE standard of 55 mpg in 2050.



the model added about 75 GW of new nuclear capacity, which took market share from coal with CCS (Figure 14).

This sensitivity analysis shows that the role of nuclear in a carbon-constrained economy is highly sensitive to its capital costs, but that the cost of complying with carbon emission limits is not very sensitive to cost of nuclear power given the other zero- and low-emission technologies available.

We also tested a run in MARKAL in which we reduced the nuclear plant lifetime from 60 years to 50 years. In that case, more nuclear retired earlier and coal with CCS filled the gap (Figure 15).

CAFE Standards Influence the Extent to Which Electric and Plug-in LDVs Penetrate the Market

In the core ACES run of MARKAL, we assumed that CAFE standards would rise to 80 mpg in 2050. However, we also tested the effect of changing that 2050 standard to 65 mpg and 55 mpg. Assuming lower CAFE standards reduces the share of electric and plug-in vehicles, replacing them with hybrids and gasoline-fueled vehicles (Figure 16). Unsurprisingly, LDV fuel consumption increases under the lower standards (Figure 17). Meanwhile, allowance prices increase with lower standards: They increased 5 percent relative to the core ACES run when CAFE standards were decreased to 65 mpg in 2050, and they increased 16 percent relative to the core ACES run when CAFE standards were decreased to 55 mpg in 2050.

Transit Mode Shifts That Eliminate or Redirect LDV Vehicle Miles Travelled Save Money

In our core ACES run in MARKAL, we assumed that the vehicle miles traveled of light-duty vehicles would be reduced 5 percent vs. BAU in 2020 and 9 percent in 2030 —with 85 percent of that reduction coming from an elimination of VMT and the remaining 15 percent being redirected to public transit. We ran two sensitivity cases in which we tested an aggressive VMT reduction case (the middle scenario in Figure 18, with LDV VMT reduced 15 percent vs. BAU in 2020, going to 23 percent in 2030) and a "no

Figure 17. LDV fuel consumption in MARKAL, under the ACES core run, a sensitivity in which the CAFE standard in 2050 is lowered from the 80 mpg in the core run to 65 mpg, and another sensitivity with a CAFE standard of 55 mpg in 2050.

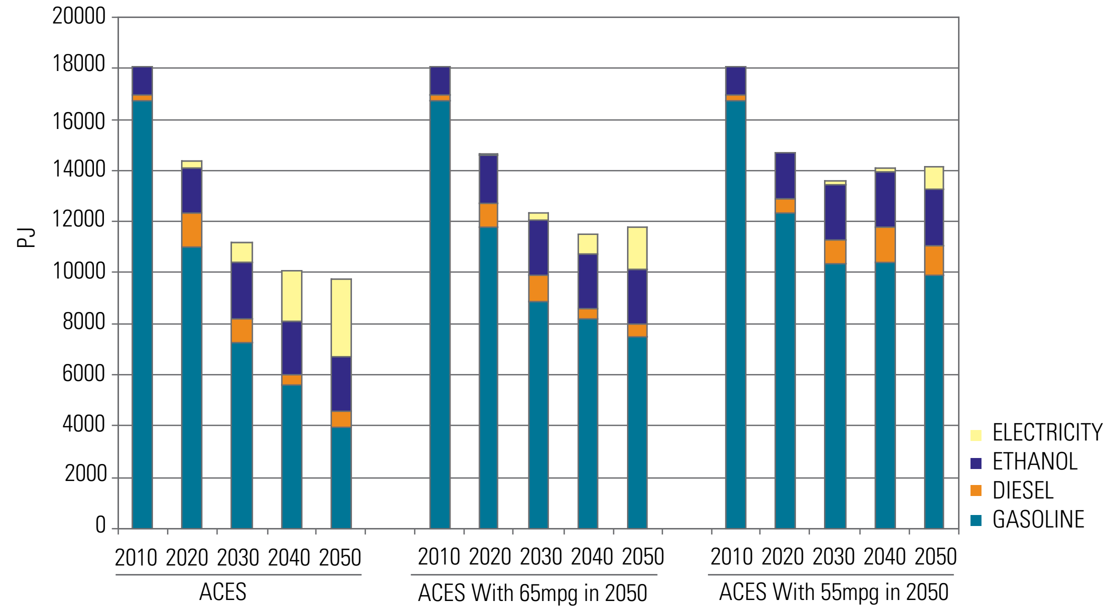


Figure 18. LDV fuel consumption in MARKAL, under the ACES core run, a sensitivity in which a higher VMT mode shift is assumed, and another sensitivity in which no VMT mode shift is assumed.

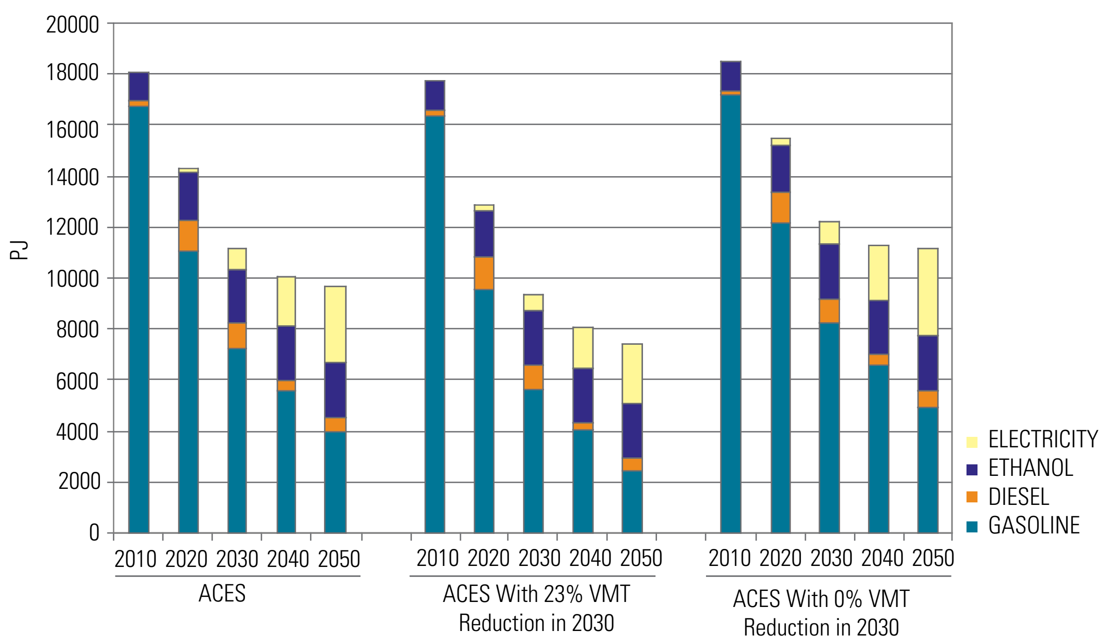
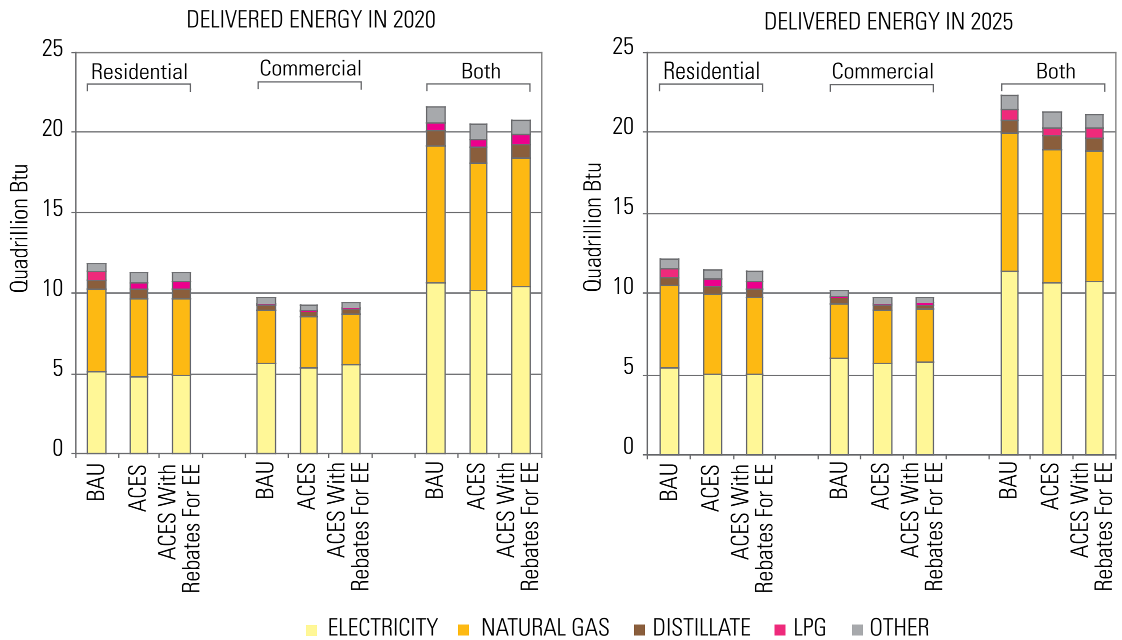


Figure 19. Delivered energy to the residential and commercial sectors in 2020 and 2025 in NEMS-NRDC, under BAU, the ACES core run, and a sensitivity off of the ACES core run in which energy efficiency is approximated through allocating 10 percent of allowance value toward subsidizing the purchase of more efficient devices, as opposed to using the EIA's high technology case, as we did to approximate energy efficiency in the ACES core run.



VMT" reduction case (with no reductions in LDV VMT vs. BAU). For the aggressive VMT reduction case we maintained the assumption that 85 percent of the VMT reduction would be eliminated and the remaining 15 percent would be redirected to public transit. Total oil consumption in the transportation sector in 2030 is 0.6 million barrels per day lower in this aggressive VMT case than in the core case and 0.3 million barrels per day higher in the no VMT reduction case. Also, allowance prices in the aggressive VMT case are 12 percent lower than in the core ACES run and the no VMT assumption increases prices 7 percent.

Alternative Approach to Reflecting Energy Efficiency Provisions

In our core NEMS-NRDC run of ACES, we approximated the effect of the energy efficiency provisions in the bill by adopting the EIA's high technology case, which has more efficient devices coming onto the market faster than in the base case. In order to test an alternative way of modeling the effect of the energy efficiency provisions, we also ran another sensitivity case in which we assumed 10 percent of allowance value would be used to subsidize residential and commercial consumers' purchases of more efficient devices in space heating, space cooling, water heating, and commercial lighting (referred to as the rebate case). The resulting decrease in consumption was nearly identical to that in the ACES core run (Figure 19), which leads us to believe that using the high technology case is a fair approach to approximating the effect of the energy efficiency provisions. However, the reductions come in different categories of end-use devices: While the core run sees energy efficiency savings mostly from improvements in building shells and electronic equipment (e.g., personal computers), the rebate case only has reductions in the end-use categories where rebates were applied (space heating, space cooling, water heating, and commercial lighting).

CHAPTER 5

Recommendations for a Strong and Effective Climate Bill

NRDC believes that although ACES establishes a firm foundation for helping the United States achieve economic recovery, energy security, and resource sustainability, six key strengthening amendments would allow the United States to reduce emissions more quickly for substantially greater savings.

1. **TIGHTEN THE 2020 CAP FROM THE CURRENT 17 PERCENT BELOW 2005 LEVELS TO 20 PERCENT BELOW 2005 LEVELS**
   More rapid emissions reductions will reduce the risks of catastrophic global warming and strengthen the United States' negotiating position in working to secure greater commitments from other countries. The cost of doing so is reasonable—tightening the 2020 target from 17 percent to 20 percent would increase allowance prices just 6 percent, according to both NEMS-NRDC and MARKAL. Moreover, such an increase could be more than offset by the savings produced by the following strengthening amendments.

2. **INCLUDE GREATER PROVISIONS FOR ENERGY EFFICIENCY, SUCH AS MANDATING THAT ONE-THIRD OF ALLOCATIONS TO LOCAL DISTRIBUTION COMPANIES BE USED FOR ENERGY EFFICIENCY**
   There is no shortage of cost-effective opportunities for energy efficiency, and ACES has plenty of room to include greater provisions to capture that potential. According to McKinsey & Company's recent report, energy efficiency opportunities with a positive rate of return can reduce end-use energy consumption 23 percent from BAU levels in 2020 across the residential, commercial, and industrial sectors.[9] Energy efficiency is a critical cost-containment mechanism because it decreases energy demand, lowering both electric bills and allowance prices simultaneously. As a result, the cost of meeting the cap will be lower for everyone.

   In order to help America reach its full energy-saving potential, a reliable system of measurement should be established to evaluate energy efficiency performance and reward success for improving performance. More specifically, tracking changes in energy intensity by states, utilities, and other recipients of federal dollars would provide the transparency and accountability needed to ensure that energy efficiency funding and programs achieve their full potential. Also, establishing a credible, uniform assessment of the energy intensity of the residential and commercial sectors can drive friendly competition among states and local distribution companies (LDCs) and result in improved efficiency results. Furthermore, in the context of a carbon cap, federal policy makers can use a performance-based measure to reward states and LDCs for achieving aggregate-level energy efficiency improvements in the residential and commercial sectors. Such an approach would award an increasing portion of allowance value to states and/or LDCs that lower per-capita end-use energy consumption relative their own baseline—not a national average—giving all states an opportunity to compete for allowances on equal footing. For more information on how such a metric could work, please see: http://www.nrdc.org/globalWarming/cap2.0/energybargain.asp

In addition to such performance-based incentives, comprehensive clean energy and climate legislation should include additional energy efficiency provisions that promote measures such as retrofitting existing buildings and increasing the energy efficiency of new buildings in order to generate net savings using technology that exists today. A clear set of policy solutions for reaping the immediate benefits of building efficiency is available at: http://www.nrdc.org/globalWarming/cap2.0/kick.asp

3. STRENGTHEN RENEWABLE ENERGY DEPLOYMENT POLICIES

We believe that ACES would benefit from stronger renewable electricity deployment policies. Currently, the combined energy efficiency and renewable energy standard (RES) mean that the effective renewable electricity requirement for 2020 is 12 percent (because 8 percent can be met through energy efficiency). At that level, it will likely be nonbinding, with NEMS-NRDC projecting that renewables will make up 12 percent of generation in 2020 under BAU. Furthermore, current provisions related to the RES, such as exemptions for small utilities, and removing some generation technologies from the sales baseline, results in the effective RES being even lower. We recommend imposing stronger requirements for renewable generation, which would force the energy system to move closer to the ACES core scenario in MARKAL (Figure 7), with renewables constituting 22 percent of generation in 2020 and 34 percent in 2030 (vs. 17 percent in 2020 and 19 percent in 2030 in NEMS-NRDC). Whereas doing so would require greater upfront investment, learning-by-doing would bring down the capital costs of renewables more quickly, thereby making them an economical component of our clean energy economy. Furthermore, we expect that it would also result in lower allowance prices and less dependence on offsets (which are temporary solutions in that they do not transition the economy toward a sustainable low-carbon future, but rather provide a one-time means to satisfy allowance requirements).

A RES by itself would tend to favor the most developed renewables technologies that are the cheapest option currently available. As a result, emerging technologies will deploy slowly, if at all, since their higher current investment costs might prevent them from being chosen (despite the fact that learning could bring the costs of CSP down dramatically over time). One way to encourage stronger renewables deployment while also not disadvantaging more nascent technologies would be to provide different incentives to each technology group, depending on its market share. A proposal for such a policy is outlined in greater detail at: http://www.nrdc.org/globalWarming/cap2.0/files/poweringup.pdf

4. STRENGTHEN TRANSPORTATION EFFICIENCY POLICIES

Strong transportation policies, such as aggressive CAFE standards and policies that would affect transit mode shifts (smart growth, better public transit, etc.) would go a long way toward cutting the costs of ACES and improving our national energy security. As shown in the MARKAL sensitivity cases (Figures 16 and 17), CAFE standards have a large influence on the LDV technology mix, fuel consumption, and allowance prices. More specifically, allowance prices would be 16 percent higher if new vehicle fuel efficiency reaches only 55 mpg in 2050, rather than the 80 mpg specified in the ACES core run. Though there is admittedly a higher upfront cost for more efficient vehicles, fuel savings over the lifetime of the vehicle more than make up for that incremental amount. Furthermore, there is an energy security component here as well: Tighter CAFE standards result in lower fuel consumption (in 2050, having 80 mpg results in 31 percent lower LDV fuel consumption relative to a case with 55 mpg), which in turn reduces our demand for oil imports.

At the same time, smart growth policies that reduce VMT also have compelling benefits. As shown in Figure 18, strong VMT policies that encourage a transit mode shift result in dramatic changes in fuel consumption. Similarly, they lower allowance prices—the aggressive VMT case had allowance prices that were 12 percent lower than the ACES core run. For reasons of cost containment, a faster transition to a sustainable low-carbon economy, and greater energy independence, we recommend strong transportation policies.

5. IMPLEMENT EFFECTIVE OFFSET QUALITY STANDARDS

NEMS-NRDC estimates that the United States will meet the cap in part through the use of 1–2 billion offsets per year. With such significant reliance on offsets, it is essential that we establish and enforce rigorous quality standards for all offsets. More specifically, baselines need to be set carefully to ensure that what qualifies as an offset actually represents incremental abatement above BAU. Moreover, the standards should include provisions to discount appropriately for leakage and reversibility or otherwise compensate for these risks (for example, through an offset reserve or other insurance mechanisms). Our analysis indicates that unless offsets represent real incremental abatement above BAU, the environmental effectiveness of ACES could be severely compromised. At the same time, our MARKAL results show that strong complementary policies to overcome barriers to energy efficiency and renewable energy deployment can greatly reduce the need to rely on offsets, resulting in lower compliance costs and increased certainty that our environmental goals will be achieved.

6. MAINTAIN EFFECTIVE CLEAN AIR ACT AUTHORITY FOR COMPLEMENTARY PERFORMANCE STANDARDS

ACES should build on, rather than supplant, existing authority to regulate greenhouse gases under the Clean Air Act. While the emissions cap in ACES will be the main driver of emission reductions, as was the case when a cap on sulfur dioxide emissions was established in the 1990 Clean Air Act amendments, Congress should leave in place existing authority to set New Source Performance Standards and conduct New Source Review for carbon dioxide and other heat-trapping gases. Both NEMS-NRDC and, to a lesser extent, MARKAL suggest that existing highly-polluting coal fired power plants will reduce their emissions very gradually given the modest emission allowances prices forecast by these models. The EPA should retain its existing authority under the Clean Air Act to require these plants to make more substantial emission reductions if necessary to achieve ACES' overall goal of preventing dangerous climate disruption.

Endnotes

1 AEO2009 generally reflects all current legislation and regulation that are defined sufficiently to be modeled as of November 5, 2008, including EISA 2007 and EPAct 2005. In addition, it also reflects selected State legislation and regulations where implementing regulations are clear such as the October 2008 decision by the California Air Resources Board (CARB) on California's Low Carbon Fuel Standard (LCFS) requiring a 10-percent ethanol blend, by volume, in gasoline. For more information on what is included in AEO2009, please see: http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

2 Household cost refers to consumption loss per household, which represents the reduction in consumer spending for goods and services due to lower purchasing power. For the apples-to-apples comparison shown, we calculated the net present value of annual consumption loss per household from 2012 to 2030, in 2007 dollars, with 2009 as the base year and a 5 percent discount rate.

3 McKinsey & Company, "Unlocking Energy Efficiency in the U.S. Economy," July 2009, at http://www.mckinsey.com/USenergyefficiency/.

4 MARKAL does not provide the regional breakout or electricity price details that would be needed to produce comparable estimates on a state-by-state basis.

5 The graph shows the discounted system cost for 2012-2050 of ACES relative to a BAU case with the VMT reductions built in already. As a result, it shows the net energy system cost of ACES without the effect of the VMT reductions.

6 We did not change the AEO 2009 assumptions for nuclear overnight investment costs, though we believe them to be low at $3,375 per kW (in 2007 dollars). If we had adjusted them to reflect levels more consistent with current experience, we expect that nuclear would have factored into the generation mix less strongly.

7 National Energy Technology Laboratory, "Storing CO_2 and Producing Domestic Crude Oil with Next Generation CO_2-EOR Technology," January 2009.

8 Moving Cooler, "Moving Cooler: Analysis of Transportation for Reducing Greenhouse Gas Emissions," July 2009, at http://movingcooler.info/.

9 McKinsey & Company, "Unlocking Energy Efficiency in the U.S. Economy," July 2009, at http://www.mckinsey.com/USenergyefficiency/.