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TECHNICAL REPORT

# Impacts on U.S. Energy Expenditures and Greenhouse-Gas Emissions of Increasing Renewable-Energy Use

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Prepared for the Energy Future Coalition


Environment, Energy, and Economic Development

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# Summary

## Introduction

Sharply higher prices for oil over the past several years, concerns about energy security, and growing worries about global warming have greatly increased interest in expanding renewable energy in the United States. Substituting renewable energy for fossil fuels would reduce emissions of carbon dioxide ($CO_2$), the most prevalent "greenhouse gas" (GHG) associated with global warming. By lowering demand for oil, substitution of renewable fuels could contribute to national energy security. In addition, increased renewable-energy supplies from rural areas could enhance rural incomes in the United States.

The penetration of renewable energy into the marketplace has been small, providing 9.5 percent of total U.S. electricity use (mostly hydroelectric power) and only around 1.6 percent in motor fuels in 2006. The market penetration of renewables has been held back principally by their higher cost relative to fossil energy. But cost relationships could change in the future.

In this report, RAND researchers assess the potential impact on U.S. consumer energy expenditures of producing 25 percent of U.S. electric power and motor vehicle–transportation fuels from renewable resources by the year 2025 and to examine the potential effects of this mix of energy use on national $CO_2$ emissions. The baseline for the comparisons was expenditures and $CO_2$ emissions in 2025 as drawn from the reference-case tables of the Energy Information Administration's (EIA's) 2006 *Annual Energy Outlook* (AEO) (EIA, 2006a, 2006b). However, the researchers also consider the implications of future energy prices much higher than these reference-case values.

The researchers focused on the impacts of expanded renewables use in the motor-fuel and electricity sectors, while taking into account the impacts that such changes in energy use would have in other domestic and international energy markets. The analysis did not address broader measures of economic impacts from the introduction of more-costly energy sources or the economic impacts of potential competition between food and fuel in the production of biomass-based energy production. Assessing impacts on consumer expenditures and $CO_2$ emissions requires many assumptions about future energy costs and demands, factors that remain highly uncertain. These factors include not just the rate of advance in renewable-energy technologies but also the costs of fossil energy (in particular, the future price of oil) and the availability of renewable resources (in particular, biomass).

To facilitate addressing these uncertainties, basic supply-and-demand–type models were used to describe possible snapshots of 2025 energy markets in terms of prices, quantities used, expenditures, and $CO_2$ emissions. In the analysis of model results, the goal was *not* to identify any single "most likely" scenario for future energy costs or patterns of energy use. Instead, we

considered a large number of scenarios based on ranges of values for key parameters to illustrate the range of possible impacts on energy expenditures and $CO_2$ emissions that might result from the renewable-energy requirements.

## Key Findings

Based on our analysis of the 25 percent renewable-energy requirements, we found the following:

- Substantial variation exists in potential expenditure changes across scenarios, especially in the motor-vehicle transportation–fuel market. Depending on the assumptions made, expenditure changes can be minimal or show a very substantial increase.
- The government's approaches to implementation of the policy requirements—particularly with respect to motor-fuel pricing—have important effects on consumer behavior and expenditures. In particular, passing the cost of more expensive renewable fuels to final pump prices will increase the direct impacts on expenditure, but it will also serve to generate improvements in energy efficiency. Subsidizing more expensive fuels will mitigate the direct impacts on expenditure, but only by transferring the expenditure to the government budget.
- Meeting the 25 percent requirements with relatively low expenditure impacts requires significant progress in renewable technologies. Biomass availability, in particular, is one of the factors that can have the greatest implications for consumer expenditure changes. Another important factor is the degree of technical advance in wind power. The U.S. Department of Energy (DOE) has set ambitious program goals for renewable technologies that, if achieved, would significantly moderate the expenditure impact of the 25 percent requirements. But if progress falls short of these goals, the requirements could be expensive. This is a real possibility, given the ambitiousness of these particular goals and the general tendency for technology-development programs to have optimistic early stage cost estimates.
- Lower levels of the requirements (15 or 20 percent) decrease expenditure changes more than proportionately, although they also result in lower $CO_2$ emission reductions than the 25 percent requirements.
- The 25 percent requirements can reduce $CO_2$ emissions significantly, but the additional cost of energy supply per unit of reduced $CO_2$ emissions can vary considerably. Unless there is very substantial cost-reducing technical innovation for expanding renewables, the incremental cost would be higher than the levels of incremental costs often encountered in current policy discussions.

## Implications

While the objective of significantly increasing renewable-energy use in motor fuels and electricity seems technically achievable, our findings indicate that the resulting impact on consumer energy expenditures is quite uncertain. The wide range of potential expenditure impacts reflects several significant uncertainties with respect to the future availability and cost of

renewable-energy sources. Of all the uncertainties, none looms larger than those affecting the cost of bringing significant new volumes of biofuels to market.

Given this finding, *a large, inexpensive, and easily converted biomass supply is necessary for significantly increased renewable-energy use to have relatively low impact on consumer energy expenditures. The significant resulting increase in biomass usage would require harvesting various energy crops at a scale that vastly exceeds current practice.* Greatly increased biomass production could be accompanied by adverse environmental and economic impacts due to land conversion. There is also the possibility that land-use changes engendered by higher reliance on biomass could result in a temporary increase in GHG emissions. *Technical advances in the provision of economically and environmentally sound feedstock should be a top priority for R&D programs focused on increasing biomass-based energy supplies.*

The renewable-fuel requirements reduce global demand for petroleum and lower the international price of crude oil. This oil price impact from fuel diversification can be seen as enhancing energy security. Energy security also depends on how exposed the economy is to oil price shocks. Substitution of relatively costly renewable fuels for fossil-based alternatives at a 25 percent level may do relatively little to mitigate that risk, since, in competitive wholesale and retail fuel markets, the prices of the alternatives will be highly correlated with the price of oil.

Our analysis also indicated that increasing the share of renewables to 25 percent can significantly reduce $CO_2$ emissions. However, the incremental increase in energy cost per unit of $CO_2$ reduction varies widely depending on circumstances, reaching high levels unless there is very substantial cost-reducing innovation in expanding renewables. Fossil-fuel prices that are higher than the baseline levels assumed in this analysis would induce greater use of renewable energy and thus reduce the incremental cost of achieving 25 percent renewable energy (thereby also lessening the need for setting this as a policy target). High fossil-fuel prices also improve the economics of other alternatives that can reduce GHG emissions and improve energy security, such as energy efficiency and unconventional energy sources.

Given these findings, *increased renewables use can reduce $CO_2$ emissions and could enhance energy security by reducing petroleum use; however, these gains likely could be realized more cost-effectively through a diverse portfolio of energy measures that improve energy efficiency, reduce $CO_2$ emissions, and increase the availability of energy sources other than conventional petroleum. Moreover, while the pricing of renewable fuels can be used to insulate consumers from price changes, this approach adversely affects energy efficiency and the development of other alternatives and increases pressure on the federal budget from subsidizing higher-cost fuels.*

Requirements for renewable-energy use could be a part of the portfolio, and they already are being developed by a number of states for use in the electricity sector. They could be justified conceptually as a way to reduce initial investment barriers by stimulating greater private-sector R&D and learning through doing and as an alternative to price-based policy instruments if those are handicapped by political constraints. Our findings suggest that renewables requirements on the order of 25 percent could be met with modest impacts on consumer energy expenditures if there is substantial progress in several key renewable-energy technologies and biomass feedstock production. However, if significant technological advances do not occur in these areas, then the policy could become quite costly. Moreover, our analysis provides only a snapshot of annual expenditures in 2025 and does not deal with the higher outlays in intermediate years of the transition, when substantial new capital would have to be invested and technologies are still relatively underdeveloped. These observations suggest that any requirements for increased use of renewables not only should be part of a larger policy portfolio, but also

should be phased in gradually and carefully reviewed periodically to assess how technology is advancing before requirements are raised further.