**STATEMENT OF**

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Mr. Chairman and Members of the Committee:

I appreciate the opportunity to appear before you today to discuss renewable energy markets in the United States.

The Energy Information Administration (EIA) is an autonomous statistical and analytical agency within the Department of Energy. We are charged with providing objective, timely, and relevant data, analysis, and projections for the use of the Department of Energy, other government agencies, the U.S. Congress and the public. We do not take positions on policy issues, but we do produce data and analysis reports that are meant to help policy makers determine energy policy. Because we have an element of statutory independence with respect to the analyses that we publish, our views are strictly those of EIA. We do not speak for the Department, nor for any particular point of view with respect to energy policy, and our views should not be construed as representing those of the Department or the Administration. However, EIA's baseline projections on energy trends are widely used by government agencies, the private sector, and academia for their own energy analyses.

The projections in this testimony are from the *Annual Energy Outlook 2001* (AEO2001) published by EIA in December 2000, which provides projections and analysis of domestic energy consumption, supply, prices, and energy-related carbon dioxide emissions through 2020; and from the report *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard (Strategies)*, released by EIA in July 2001. The projections in these reports are not meant to be exact predictions of the future, but represent possible alternative energy futures, given technological and demographic trends, current laws and regulations, and consumer behavior as derived from known data. EIA recognizes that projections of energy markets are highly uncertain, subject to many random events that cannot be foreseen, such as weather, political disruptions, strikes, and technological breakthroughs. In addition to these short-term phenomena, long-term trends in technology development, demographics, economic growth, and energy resources may evolve along a different path than projected in the reference case, many of which are explored through alternative cases such as the High Renewables case presented in this testimony.

**Energy Consumption to 2020**

Total energy consumption is projected to increase from an estimated 99.1 quadrillion British thermal units (Btu) in 2000 to 128.2 quadrillion Btu in 2020, an average annual increase of 1.3 percent. Energy consumption in the United States increased from 67.9 quadrillion Btu in 1970 to 81.0 quadrillion Btu in 1979, with a downturn in 1974 and 1975 following the 1973-74 oil price increases associated with the first oil embargo. During the early 1980s, energy consumption again declined to 73.3 quadrillion Btu in 1983, due in part to the second oil price increase. Since 1983, energy consumption has been generally increasing, with an average annual increase of 1.8 percent through 2000.

Total renewable energy consumption, including ethanol used in gasoline, is projected to increase from 6.9 quadrillion Btu in 2000 to 8.6 quadrillion Btu in 2020, an average annual growth of 1.1 percent (Figure 1). In 1970, renewable energy consumption in the United States was 4.1 quadrillion Btu. Renewable energy resources include hydroelectric power, wood, and waste, with small amounts of geothermal, wind, and solar resources.[1] The share of total energy consumption that is derived from renewable sources is projected to be 7 percent in 2020, approximately the same share as in 2000. In 2020, about 54 percent of renewables is expected to be used by electricity generators (excluding cogenerators) and the rest for dispersed heating and cooling, industrial uses (primarily cogeneration), and fuel blending (Figure 2).

These projections incorporate the impacts of renewable-related laws and regulations, including the Production Tax Credit (PTC) for new electric generating capacity powered by wind and closed-loop biomass (currently in effect through December 31, 2001) established by the Energy Policy Act of 1992; the Renewable Energy Production Incentive established by the same legislation; and various State initiatives, including the California AB1890 subsidy program for qualifying renewable energy facilities, and State Renewable Portfolio Standards promulgated by Arizona, Iowa, Texas, Massachusetts, Minnesota, New Jersey, and Nevada. In addition, the projections include all capacity currently under construction, for which contractual commitments have been made, or utilities have made public commitments, and are expected to come on line between now and the end of 2002. Finally, these projections assume a continuation of research and development funding by the U.S. Department of Energy at approximately the same levels as recent history through 2020. Since the reference case includes only those laws, regulations, and standards in effect as of July 1, 2000, any further extensions of the PTC, as proposed by the Bush Administration's National Energy Policy, or other proposed laws and regulations relevant to renewable energy are not included.

**Transportation**. Transportation energy demand is expected to increase at an average annual rate of 1.8 percent to 38.5 quadrillion Btu in 2020 and is the fastest growing end-use sector. The growth in transportation use is driven by 3.6-percent growth in air travel, the most rapidly increasing transportation mode, and 2.0-percent annual growth in light-duty vehicle travel, the largest component of transportation energy demand, coupled with slow growth in vehicle efficiency.

Advanced technology vehicles, representing automotive technologies that use alternative fuels or require advanced engine technology, are projected to reach nearly 2.0 million vehicle sales (12.1 percent of total projected light-duty vehicle sales) by 2020. The leading technologies are gasoline hybrid electric vehicles and alcohol flexible-fueled vehicles. The use of renewables in the transportation sector, specifically ethanol, is projected to increase at an average rate of 2.8 percent per year between 2000 and 2020. This represents a near-doubling of the use of ethanol to 0.24 quadrillion Btu by 2020. Ethanol in the form of E85 is consumed primarily by light-duty flexible-fueled vehicles and dedicated E85 vehicles, but the majority of ethanol is used for gasoline blending, about 88 percent in 2020. All alternative fuels consumed by light-duty

[1] Ocean thermal, tidal, and wave resources are not included in these projections because they are not expected to become economically viable by 2020.

vehicles are projected to displace about 230,000 barrels of oil equivalent per day by 2020, or 2.1 percent of light-duty vehicle fuel consumption.

Bans on methyl tertiary butyl ether (MTBE) as a motor gasoline oxygenate in a number of States due to groundwater contamination may stimulate additional ethanol consumption as a substitute for MTBE. While the forecast included all eight State bans as of the summer of 2000, five States have instituted bans since that time, meaning that future ethanol consumption could be higher as a result of those and possible additional bans by other States.

**Residential and Commercial**. Residential energy consumption is projected to increase at an average annual rate of 1.1 percent, reaching 24.6 quadrillion Btu in 2020. The growth is led by energy demand for a variety of electricity-using equipment and appliances. Residential electricity use is projected to increase at an annual rate of 1.8 percent.

Commercial sector energy consumption is projected to increase at an average rate of 1.3 percent annually, to 21.3 quadrillion Btu in 2020. Similar to the residential sector, electricity consumption for telecommunications, computers, office equipment, and other appliances is the fastest growing area, with total commercial electricity demand increasing at an average annual rate of 1.8 percent.

Currently, the combined residential and commercial buildings sectors use about 0.6 quadrillion Btu of renewable energy, primarily wood consumed for residential space heating and secondary heating. This is expected to decline slightly through 2020. Renewable energy is also used in applications such as ground-source heat pumps that use geothermal energy for heating and cooling and photovoltaic (PV) solar systems that generate electricity. Grid-connected PV solar systems on buildings are projected to comprise over 350 megawatts of distributed generating capacity by 2020, aided in large measure by programs such as Million Solar Roofs that promote growth in the PV market.

**Industrial**. Industrial energy demand is projected to increase at an average rate of 1.0 percent per year, reaching 43.7 quadrillion Btu in 2020. Total industrial output is expected to grow at an average rate of 2.9 percent per year; however, the fastest growing industrial sector is non-energy-intensive manufacturing with an average annual growth of 3.4 percent. Energy-intensive manufacturing and nonmanufacturing have growth rates of 1.2 and 1.6 percent, respectively. This structural shift in the industrial sector, combined with ongoing efficiency improvements, helps to moderate the increase in industrial energy demand.

Consumption of biomass byproducts in the pulp and paper, lumber, and food industries accounts for most of the renewable energy consumed in the industrial sector. Biomass consumption is projected to increase from 2.0 quadrillion Btu in 2000 to 2.9 quadrillion Btu in 2020, a 1.9-percent average annual growth rate. Biomass often is used in cogeneration, the simultaneous production of useful thermal energy and electricity. The higher projected availability of biomass leads to additional biomass-based cogeneration capacity, which is projected to increase from an estimated 4.6 gigawatts in 2000 to 7.5 gigawatts in 2020, a 2.5-percent average annual growth rate.

**Electricity Generation**. During the 1960s, electricity demand grew by more than 7 percent per year, nearly twice the rate of economic growth (Figure 3). In the 1970s and 1980s, however, the ratio of electricity demand growth to economic growth declined to 1.5 and 1.0, respectively. Several factors have contributed to this trend, including increased market saturation of electric appliances, improvements in equipment efficiency and utility investments in demand-side management programs, and more stringent equipment efficiency standards. Throughout the forecast, growth in demand for office equipment and personal computers, among other equipment, is dampened by slowing growth or reductions in demand for space heating and cooling, refrigeration, water heating, and lighting. The continuing saturation of electricity appliances, the availability and adoption of more efficient equipment, and efficiency standards are expected to hold the growth in electricity sales to an average of 1.7 percent per year between 2000 and 2020. This is lower than the expected 2.9-percent annual growth in gross domestic product, although the projected increases in electricity usage for information technology such as computers, scanners, fax machines, and other equipment will partially offset the efficiency improvements.

Total grid-connected electricity generation from renewable sources is projected to increase from 363 billion kilowatthours in 2000 to 448 billion kilowatthours in 2020 (Figure 4). Renewables decline from a 9.5-percent share of electricity generation in 2000 to 8.5 percent in 2020. Generation from renewables other than hydroelectricity is projected to increase from 84 billion to 148 billion kilowatthours between 2000 and 2020, increasing slightly from a 2.2-percent share of total generation in 2000 to a 2.8-percent share in 2020. Other than recovering from an abnormally dry year in 2000, conventional hydroelectricity is expected to remain essentially unchanged through 2020. Most of the projected increase in non-hydro renewables is expected from biomass (2.4 percent annual growth rate), waste (including landfill gas) (1.3 percent annually), geothermal energy (4.0 percent annual growth rate), and wind power (6.9 percent annual growth rate) (Figure 5). State mandates and other incentives, including the Federal production tax credit for generation from wind, encourage much of the growth in renewables, particularly in the earlier part of the forecast period.

Further penetration of renewables is slowed by the total cost of renewable generation relative to fossil-fired technology. Despite cost reductions that are projected over time, the cost per kilowatthour of building new wind, biomass, or geothermal generation is expected to remain higher than that of either coal or natural gas-fired combined cycle generation through 2020 (Figure 6). Most of the new wind capacity is projected to occur as a result of state mandates and subsidies as opposed to cost-based competition. Geothermal resources are found at some 50 specific sites in the West, with production costs varying significantly from the lowest-cost sites to the highest. Nevertheless, total nonhydroelectric renewable electricity generation is projected to grow at a faster rate than each of the conventional energy sources of generation, with the exception of natural gas. If, in reality, future natural gas supplies and prices are different than projected in the reference case, the expected outlook for renewable sources of energy could be different.

Table 1 shows the overnight capital costs and performance characteristics of new renewable and fossil fuel-based generating technologies. Of the available technologies, those that are fueled by natural gas generally have the lowest overnight construction costs, as well as low fixed operating and maintenance costs. While their fuel costs tend to be high, they are more than offset by the other cost components. Except for wind, renewable technologies are relatively more expensive than their fossil-fueled counterparts, ranging from about $1300 to nearly $3700 per kilowatt. In addition, capacity factors for the intermittent technologies, wind and solar, are about a third to a half of the factors for the fossil-fueled technologies, making the renewable technologies less suitable for baseload electricity demand compared to the fossil technologies.

There are other barriers to the adoption and production of renewable resources. As intermittent resources, wind and solar are not always available to meet the demand for electricity, limiting their value as a generation source. In order to maintain system reliability and stability, the general rule is that intermittents should comprise no more than about 10-15 percent of a system's total generation. Also, while there are large wind resources in the United States, they become progressively more expensive and difficult to exploit as the more easily developed resources are used. For example, many wind resources are available in mountainous terrain not suitable for construction of turbines, there may be objections to the siting of turbines in some areas due to environmental reasons, and transmission facilities may not be available. Some renewable resources, such as some geothermal sites, are found on or near parkland, inhibiting their potential for development. Dams required for the production of hydroelectricity, the largest of the renewable resources, have recently come under question from environmentalists due to their disruption of fish habitats and migration. Such issues may arise during the relicensing process for existing dams, and are an important factor, along with cost, in inhibiting construction of new dams altogether.

**Renewable Resources Estimates**. Renewable resources are plentiful. Total resources for the three "best" of the six classifications of available wind in the U.S. are enough to power approximately 2500 gigawatts of generating capacity, or about three times the current installed capacity base. Biomass resources are sufficient to support between 5.6 and 7.1 quadrillion Btu of consumption per year over the next 20 years, more than double the current rate of biomass consumption. Estimates of total geothermal resources, including both identified and undiscovered categories, range as high as 280 gigawatts, far above current installed geothermal capacity. However, the costs of utilizing renewable resources are considerably higher than those of coal, natural gas, and petroleum, making them less likely to be exploited than those of the fossil fuels. Factors that tend to drive up the costs vary across resource type, but include such barriers as mountainous terrain (in the case of wind), costs of exploration and proximity to parkland (geothermal), and costs of gathering plus alternative uses of the available land (biomass). In addition, because renewable resources are generally not transportable, they must be utilized near existing transmission lines, or new lines must be built to serve them. This tends to further limit their competitive position compared to the fossil fuels. Finally, as discussed earlier, a number of environmental issues, such as questions of noise and visual pollution related to wind turbines, must be addressed in order to fully utilize the available resources.

## Alternative Cases

In order to show the impact of alternative assumptions concerning the key factors driving renewable energy markets, the following are summaries of alternative cases examining more optimistic cost and performance assumptions for renewable generating technologies and assuming a renewable portfolio standard (RPS), which requires a fixed percentage of electricity sales to be produced from renewable sources of generation.

**High Renewables**. A high renewables case assumes more favorable characteristics for nonhydroelectric renewable generating technologies than in the reference case, including lower capital cost, operations and maintenance costs, increased biomass fuel supplies, and higher capacity factors for solar and wind generation. The assumptions in this case approximate the renewable energy technology goals of the U.S. Department of Energy. Under these assumptions, total generation from nonhydroelectric renewables is projected to reach 242 billion kilowatthours in 2020, compared with 148 billion kilowatthours in the reference case, increasing from 2.8 percent of total generation to 4.6 percent (Figure 7). Most of the higher renewable generation in this case is from geothermal (40 billion kilowatthours above the reference case) and wind (51 billion kilowatthours higher than the reference case).

**Renewable Portfolio Standard Cases**. Under a Renewable Portfolio Standard (RPS), a fixed percentage of electricity sales are required to be produced from renewable sources of generation. Some RPS proposals have included hydroelectricity as a qualifying source, but most have considered non-hydroelectric technologies only. In the *Strategies* report, EIA analyzed the impacts of both a 10 percent and a 20 percent RPS, as one potential component of an emissions-reduction strategy.

In the RPS 20% case, it was assumed that the RPS requirement would be phased in over a 20-year period, with 10 percent of electricity sales met by renewable generation by 2010, and 20 percent of electricity sales by 2020. In this case, the RPS is projected to lead to rapid development of new renewable technologies as it is phased in. By 2020, total non-hydroelectric renewable generation would be 947 billion kilowatthours, more than six times the level in the reference case. The primary renewables expected to be developed would be biomass, wind, and geothermal, with some contribution from landfill gas (Figures 8 and 9). With increased generation from nonhydroelectric renewables, generation from natural gas is projected to be lower than in the reference case (Figure 10).

The development of the large amount of renewables that would be needed to satisfy the 20-percent RPS requirement has cost and price implications. Reaching the 20-percent target is expected to require increasing use of more expensive renewable options, and the renewable credit price (effectively, the subsidy paid to owners of nonhydroelectric renewable generating capacity to induce the required level of generation) is expected to become quite high. By 2010, the renewable credit price is expected to be about 4.5 cents per kilowatthour, rising to 5 cents by 2020 (Figure 11). Because electricity producers must hold allowances representing the RPS percentage of their total generation, the impact on prices would be approximately that percentage of the cost of an allowance, e.g., in the RPS 20% case about 1 cent per kilowatthour in 2020. Lower natural gas prices due to reduced use by electricity generators, however, dampen the impact on electricity prices somewhat. As a result, the price of electricity in the RPS case is expected to average about 3 percent (about 0.2 cents) higher than in the reference case in 2010 and 4 percent higher in 2020.

In the RPS 10% case, in which 10 percent of electricity sales in 2020 must be produced by renewable-based generation, the lower target for nonhydoelectric renewable generation reduces the need for power plant builders to develop renewable projects that are as expensive as those required in the RPS 20% case. As a result, electricity prices in the RPS 10% case are projected to be less than 1 percent higher than in the reference case. Each of the renewable technologies is projected to increase its generation compared to the reference case (except the solar technologies), but with a smaller response than in the RPS 20% case. Geothermal, biomass, and wind-based generation show the largest increases over the reference case.

**Energy Policies and Programs**. Due to the policy neutrality of EIA, we do not propose or advocate any particular policies and programs. We do note that, in general, there are a wide range of policies that could alter the energy future described in this testimony by encouraging the development and adoption of additional renewable technologies. Such policies include, but are not limited to, programs to foster research, development, and deployment of renewable technologies, government-industry partnerships, voluntary programs, tax credits and other financial incentives, and renewable portfolio standards. The Administration's National Energy Plan proposes an extension of the Production Tax Credit for wind and closed-loop biomass, and extends it to all new biomass capacity. Such an extension could be expected to increase the penetration of wind-based generating capacity, based on the industry's response to the existing PTC, scheduled to expire at the end of this year. In 2001, nearly 2 gigawatts of new wind-based capacity are expected to be completed, most of which would not have been built in the absence of a PTC. Even though additional subsidies are generally required in concert with the PTC to make such capacity commercially viable, the combination of State programs and a PTC extension could be expected to create additional opportunities for wind-based generation through 2006. For biomass, the PTC is less likely to have a major impact, mainly due to the higher capital costs for constructing biomass capacity, and the relatively high fuel costs compared to other generating technologies such as coal- or natural gas-fired capacity.

**Conclusion**. Over the forecast period, we expect the use of renewable sources of energy to increase; however, this increase is expected to proceed at a relatively slow pace, due in part to the relative costs of these technologies compared with fossil-fueled technologies. Technology costs or fossil fuel prices that differ from those in the projections could alter the outlook for renewables. In addition, increased research and development funding or a renewable portfolio standard, stemming, for example, from heightened environmental concerns, could also provide a more favorable economic climate for the penetration of renewable generating capacity, although at a higher cost to the taxpayer or the consumer.

Thank you, Mr. Chairman and members of the Subcommittee. I will be happy to answer any questions you may have.

| Table 1. Cost and Performance Characteristics of Electric Generating Technologies | | | | | |
|---|---|---|---|---|---|
| Technology | Overnight Construction Cost, (1999$/kilowatt) | Variable Operating and Maintenance Costs (1999 cents/kilowatt-hour) | Fixed Operating and Maintenance Costs (1999$/kilowatt) | 2000 Fuel Costs (1999$/ million Btu) | Maximum Capacity Factor (percent) |
| Biomass | 1464 | .283 | 43.88 | 2.39 | 80 |
| Wind | 919 | .000 | 26.00 | 0.00 | 32 |
| Geothermal | 1626 | .000 | 70.69 | 0.00 | 87 |
| Solar Thermal | 2394 | .000 | 46.72 | 0.00 | 42 |
| Solar Photovoltaic | 3681 | .000 | 9.85 | 0.00 | 28 |
| Landfill Gas | 1304 | .001 | 94.01 | 0.00 | 90 |
| Pulverized Coal | 1021 | .330 | 22.85 | 1.17 | 85 |
| Integrated Coal Gasification | 1220 | .078 | 31.89 | 1.17 | 85 |
| Conventional Natural Gas Combined Cycle | 424 | .051 | 15.24 | 4.45 | 87 |
| Advanced Natural Gas Combined Cycle | 533 | .051 | 14.12 | 4.45 | 87 |
| Conventional Natural Gas Combustion Turbine | 315 | .010 | 6.30 | 4.45 | 92 |
| Advanced Natural Gas Combustion Turbine | 440 | .010 | 8.94 | 4.45 | 92 |
| Source: Energy Information Administration | | | | | |

**Figure 1. Energy Consumption by Fuel, 1970-2020 (quadrillion Btu)**

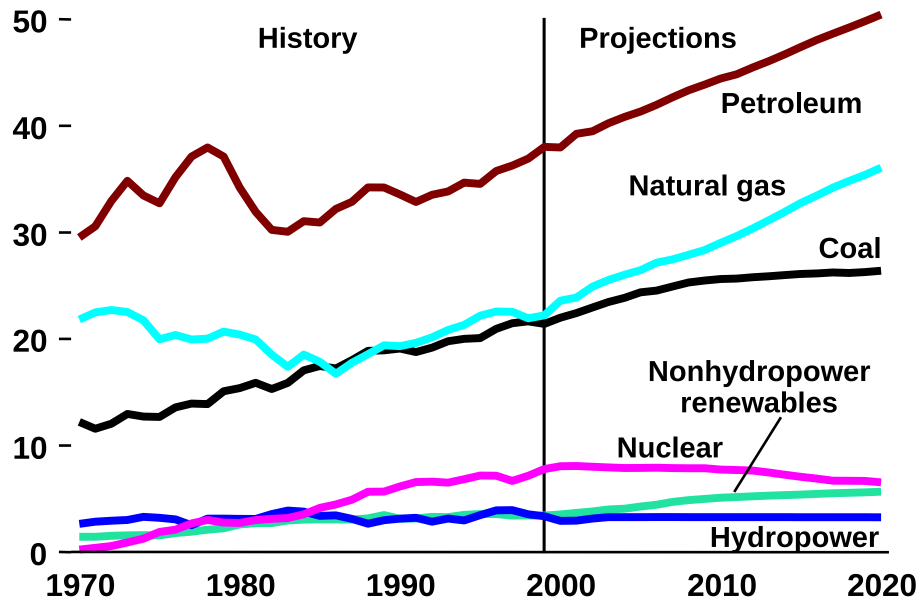



**Figure 2. Renewable Energy Consumption by Sector, 1999-2020 (quadrillion Btu)**

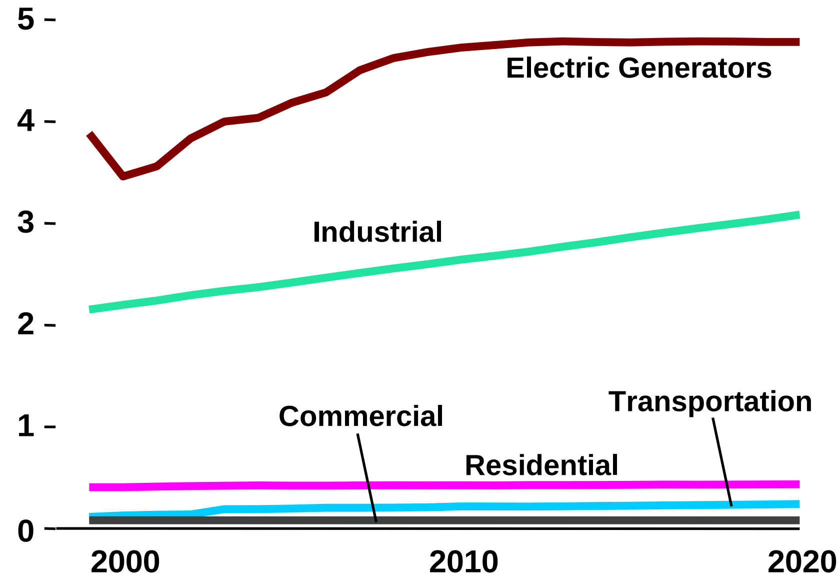



**Figure 3. Population, Gross Domestic Product, and Electricity Sales, 1965-2020 (5-year moving average annual percent growth)**

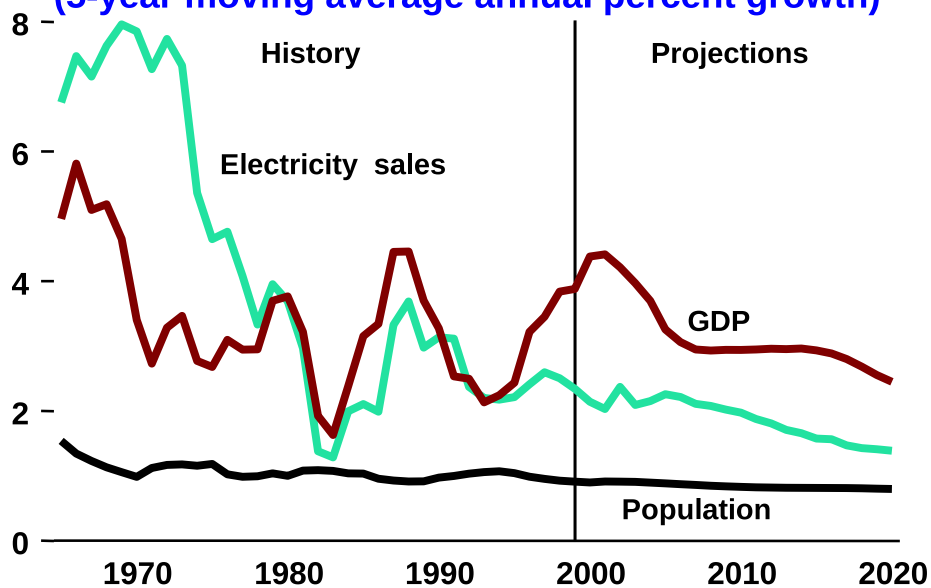



**Figure 4. Electricity Generation by Fuel, 1970-2020 (billion kilowatthours)**

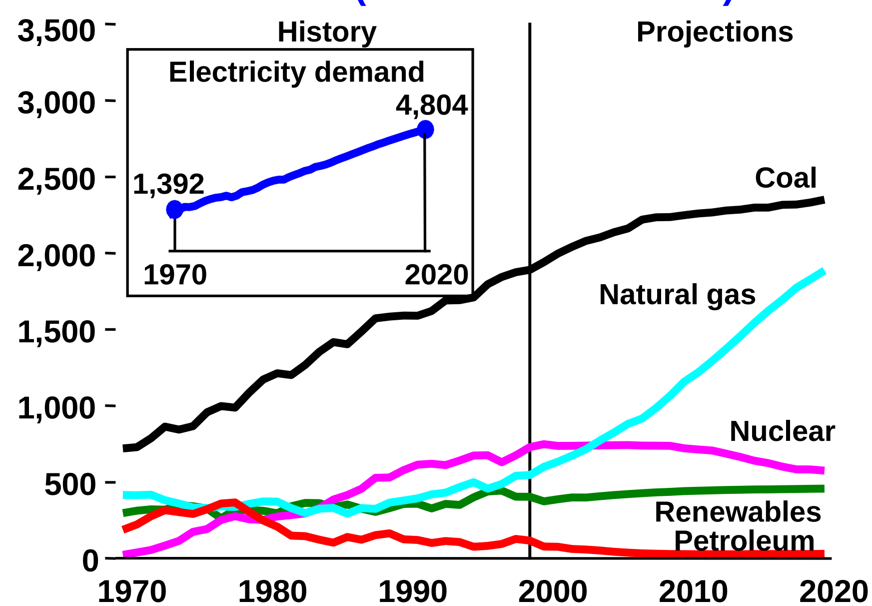


**Figure 5. Nonhydroelectric Renewable Electricity Generation by Energy Source, 2000, 2010, and 2020 (billion kilowatthours)**

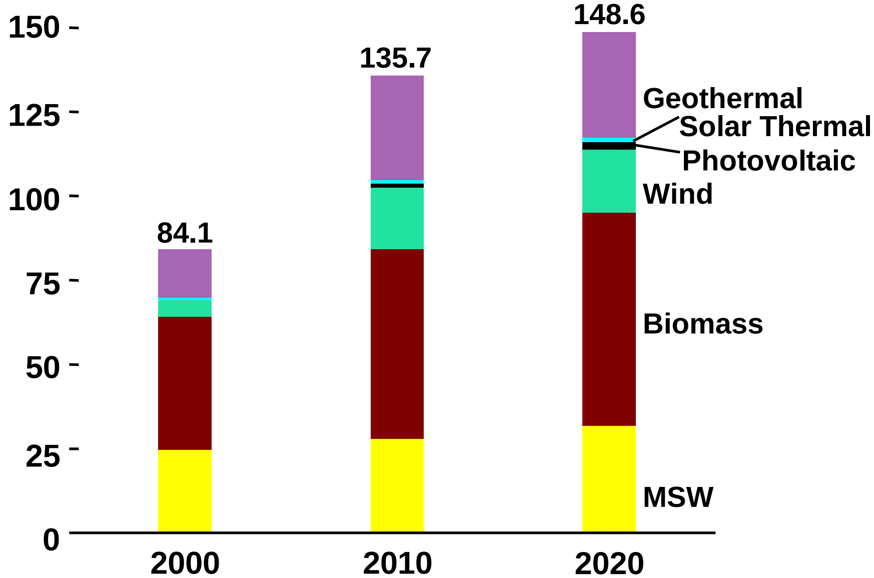



**Figure 6. Projected Electricity Generation Costs, 2005 and 2020 (1999 mills per kilowatthour)**

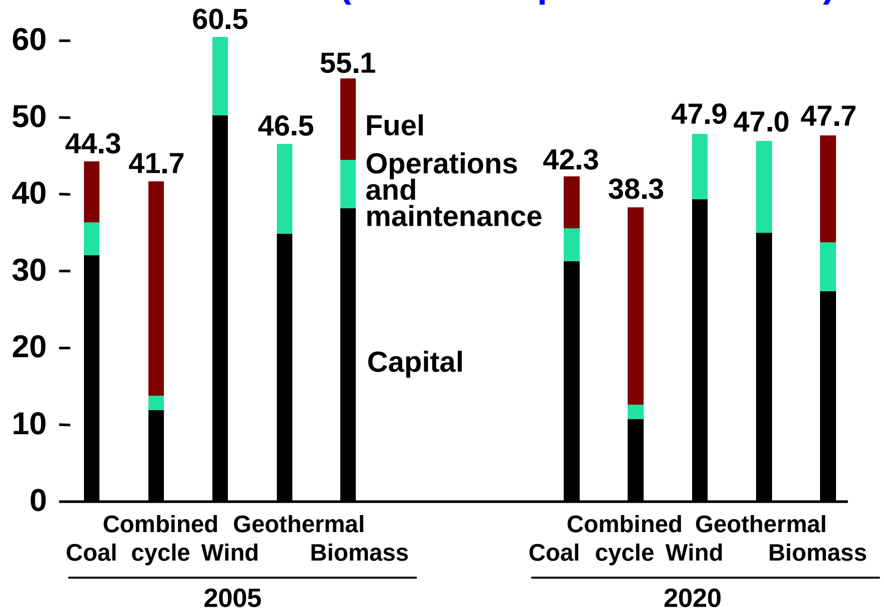



**Figure 7. Nonhydroelectric Renewable Electricity Generation by Energy Source, 2000 and 2020 (billion kilowatthours)**

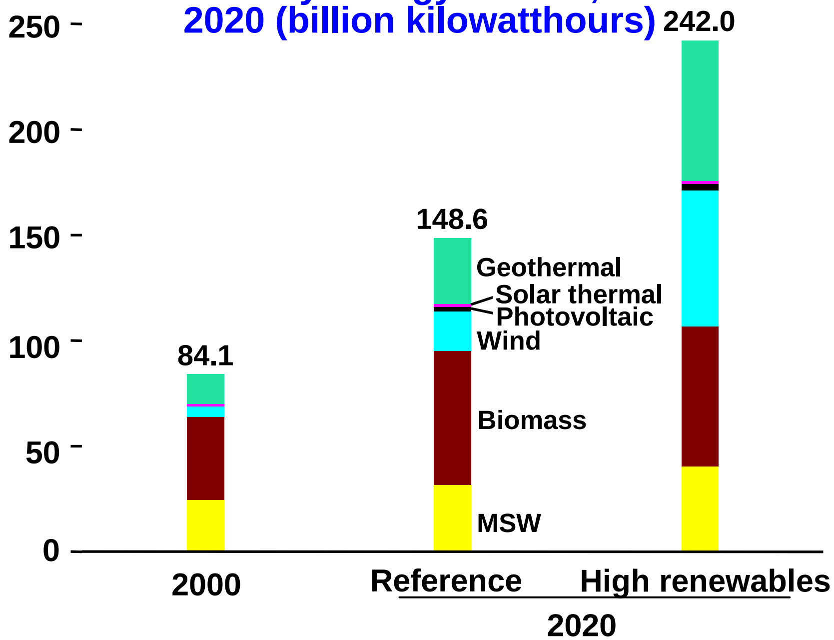
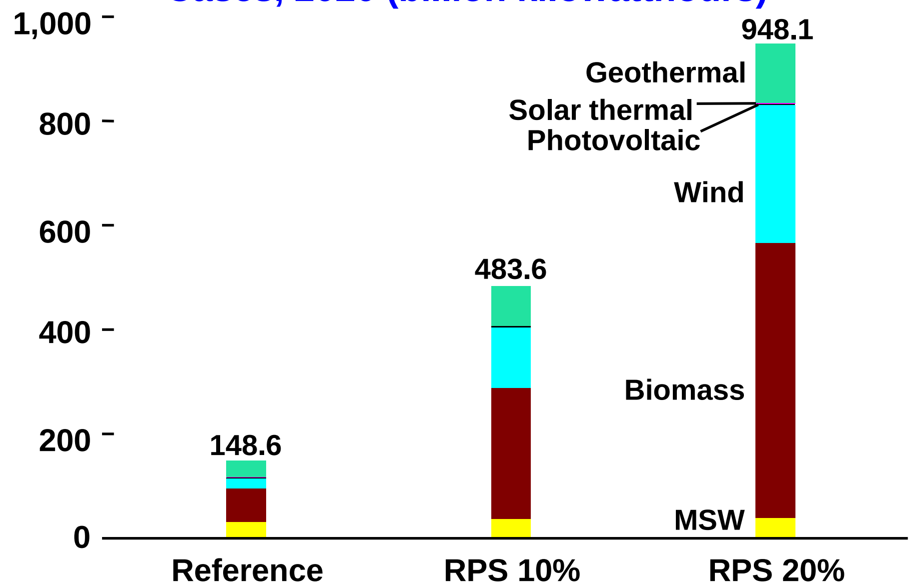
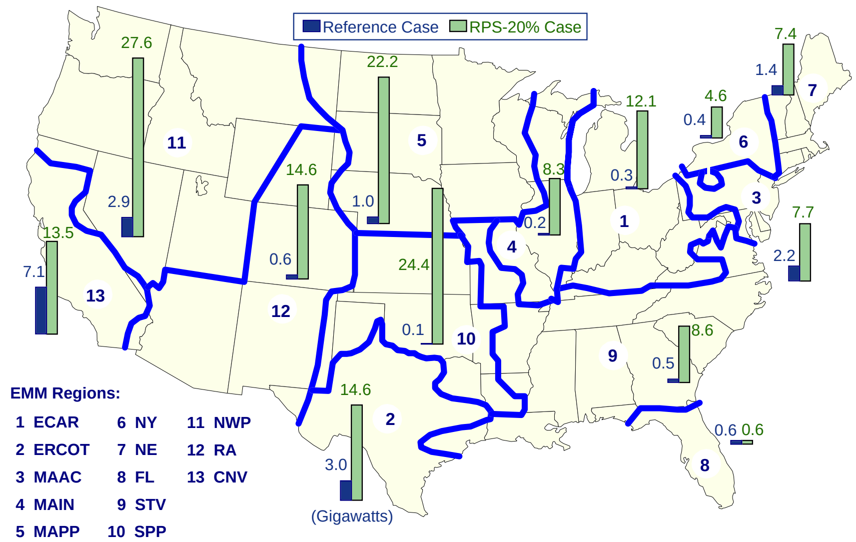


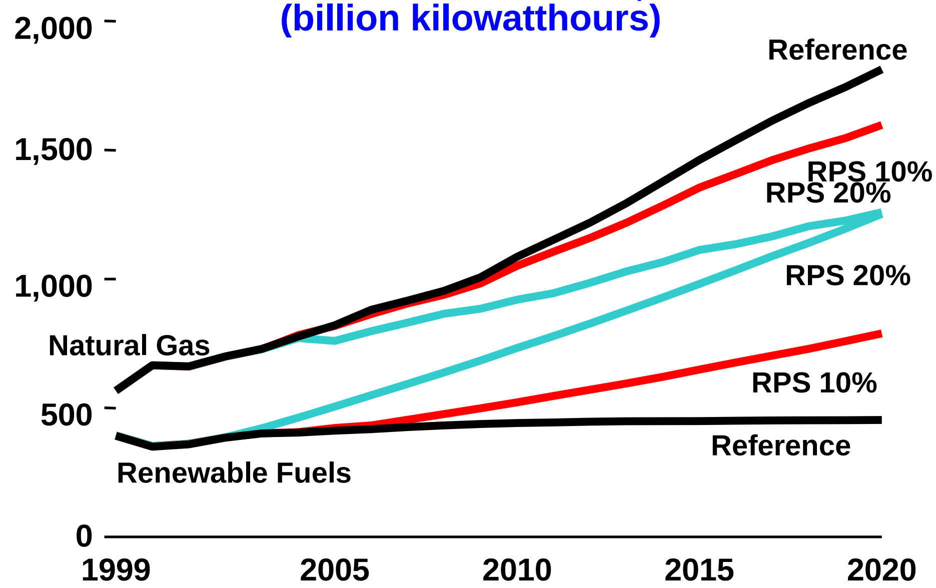

**Figure 8. Projected Nonhydroelectric Renewable Electricity Generation by Energy Source in Three Cases, 2020 (billion kilowatthours)**



## Figure 9. Cumulative Additions to Nonhydroelectric Renewable Generating Capacity by NEMS Electricity Market Module Region in the Reference and RPS 20% Cases, 2000-2020




## Figure 10. Projected Electricity Generation from Natural Gas and Renewable Fuels in the Reference, RPS 20% and RPS 10% Cases, 1999-2020 (billion kilowatthours)




## Figure 11. Projected Renewable Credit Prices in the RPS 20% and RPS 10% Cases, 2010 and 2020 (1999 cents per kilowatthour)