Energy for Colorado's Economy

Creating Jobs and Economic Growth with Renewable Energy

Environment Colorado
Research & Policy Center

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Executive Summary

Developing Colorado's renewable energy resources will yield better results for Coloradans than building more coal- or gas-fired power plants. By investing in renewable energy to meet our electricity needs, we can create jobs, stabilize energy prices, and reduce the long-term economic and environmental risk from global warming pollution.

In this report, we use an economic model to evaluate the net impacts of expanding Colorado's commitment to clean and renewable energy by extending the renewable energy standard established under Amendment 37 to 20 percent by 2020 for investor-owned utilities, plus expanding it to include Colorado's cooperative electricity companies and eligible municipal utilities with a target of 10 percent by 2020.

Renewable energy improves Colorado's economy and environment, and should form a central part of Colorado's electricity system.

Renewable energy creates jobs.

- Expanding Colorado's renewable energy standard would create a net increase of 4,100 person-years of employment through 2020. It would also increase total wages paid to workers in the state by a net cumulative total of $570 million.[1] That's approximately four times the positive employment impact and twice the wage impact of Amendment 37.

Renewable energy creates economic growth.

- Expanding Colorado's renewable energy standard would increase Colorado's share of gross domestic product (GDP) by a net of $1.9 billion through 2020. The increase in GDP under an expanded standard would be almost twice as large as under Amendment 37.

Renewable energy benefits Colorado's rural areas.

- Landowners can lease land for wind farms, creating an additional income stream. An expanded renewable energy standard would supplement landowner income with cumulative total lease payments of $50 million through 2020 (60 percent more than under Amendment 37).
- According to the National Renewable Energy Laboratory, wind energy provides 10 times more local tax revenue than a coal-fired power plant in Colorado (on an energy-equivalent basis). Expanding Colorado's renewable energy standard would generate $400 million in property taxes (total through 2020) to fund education and other local government services, mainly in rural areas of the state (70 percent more than under Amendment 37).

Renewable energy prevents pollution and conserves water.

- An expanded renewable energy standard would reduce soot, smog, mercury and global warming pollution from Colorado's electricity sector in the year 2020 by approximately 11 percent (compared to business as usual). In that year, the expanded renewable energy program would be 2.3 times as effective at preventing pollution as Amendment 37 alone.
- An expanded renewable energy standard would save a cumulative total of 18 billion gallons of water through 2020, water that otherwise would be used for steam and cooling in coal- or gas-fired plants. That amount of water (almost twice as large as under Amendment 37) could completely fill Cherry Creek Reservoir more than twice.

Renewable energy keeps more of Colorado's energy dollars in the local economy compared to coal- and gas-fired power plants.

- The National Renewable Energy Lab estimates that a Colorado wind farm has more than three times the direct economic impact of an equivalent coal-fired power plant, and more than twice the impact of a gas-fired plant.
- The NREL study calculates that wind farms keep more than twice as much money in Colorado for construction and operation and maintenance as a coal plant, and more than three times as much as a gas plant.

Colorado has more than enough renewable energy resources to make a new energy future a reality.

- Colorado has excellent wind energy resources, with an estimated technical potential more than 10 times greater than the state's entire electricity needs in 2006.
- Solar photovoltaic panels occupying just 0.15 percent of Colorado's land area could generate nearly twice as much electricity as the state used in 2006.
- Colorado also has the potential to use agricultural wastes and switchgrass for energy, with the potential to generate up to 8 percent of the state's electricity needs.

Introduction

Electricity is central to Colorado's economy. It powers everything from refrigerators to hair dryers, ski lifts to traffic lights, and from industrial equipment to air conditioners—making the modern economy possible.

Choices about how Colorado generates its electricity affect the economy, and the budgets of families and businesses across the state. However, the impact is much broader than simply the price we pay for every kilowatt-hour (kWh).

For example, different energy sources send our money to different parts of the economy—acting as either a drain or a stimulus to the state's overall economic health. For example, purchasing coal to run a power plant often sends money to Wyoming to pay for mining and transportation. In contrast, installing a wind farm on Colorado's plains keeps more energy dollars local, and has a greater positive impact on the state economy.

Some energy sources also expose Coloradans to fluctuating energy prices. Coloradans have experienced increased electricity rates over the last several years, driven primarily by higher natural gas prices. These costs have come on top of higher gasoline prices at the pump, magnifying their impact.

At the same time, Colorado's overdependence on fossil fuels exposes us to serious public health and environmental risks. Burning coal and oil has contaminated Colorado's rivers and lakes with mercury pollution and dirtied the state's air with dangerous soot and smog. It has also created massive amounts of global warming pollution, which is warming Colorado's climate—visible in early melting of winter snow, early blooming of spring flowers, more intense wildfire seasons, and a northward shift in ranges of plant and animal species.

It is in this context that we must decide Colorado's energy future.

If we extend our dependence on fossil fuels, we increase our vulnerability. As demand for natural gas and oil begins to exceed available supply, Coloradans could face rapidly increasing energy prices. Fossil energy prices will vary unpredictably, subject to natural disasters like hurricanes in the Gulf of Mexico, speculation on energy markets, and international events such as threats to oil shipments in the Persian Gulf. Increased coal consumption could delay the day when Coloradans have clean and healthy air to breathe, and fish without mercury contamination. And increasing Colorado's use of fossil fuels will only worsen the costs, risks and eventual liabilities caused by global warming—threatening the welfare of future generations, the ecosystems upon which life depends, and our standing in the global community.

Recognizing these facts, the citizens of Colorado became the first in the nation to vote on and pass a statewide renewable energy requirement in November 2004. Amendment 37 requires Colorado's top utility companies to provide a percentage of their retail electricity sales from renewable resources—3 percent by 2007, increasing to 10 percent by 2015.

However, Colorado's electricity needs are growing rapidly. Experts forecast that Colorado will use about 2.2 percent more electricity per year through 2020.[2] The renewable energy created by Amendment 37 will cover only about 20 percent of this additional electricity demand.[3]

On one hand, Colorado can choose to make up the difference with traditional technologies, like the three coal-fired power plants that Tri-State Generation and Transmission has proposed to build in Kansas and Colorado.[4] Colorado could also continue to build and operate more natural gas-fired power plants, thereby subjecting consumers to the unpredictable variability of natural gas prices.

On the other hand, Colorado could transform how it produces and consumes energy, following a Plan for a New Energy Future. This strategy would increase Colorado's reliance on renewable forms of energy such as wind, solar, and biomass power—reaching as high as 20 percent of total electricity generation by 2015. It would also tap into Colorado's vast "strategic reserves" of energy efficiency—a resource that could cost-effectively eliminate growth in demand for electricity for the foreseeable future.

In this report, we evaluate the impacts of expanding Colorado's commitment to renewable energy. In a future report, we will examine the impacts of deploying a serious energy efficiency program to reduce overall demand for electricity—and thus the need to build any coal-fired power plants.

Here we compare the impacts of a scenario in which Colorado implements Amendment 37, but builds coal-fired power plants to provide additional energy; with a scenario in which Colorado expands the renewable energy requirements of Amendment 37 to 20 percent by 2020 for investor-owned utilities, and includes cooperative electricity companies and eligible municipal utilities with a target of 10 percent renewable generation by 2020. We also compare each scenario to a hypothetical business-as-usual case in which Colorado does not pursue renewable energy.

We use an input-output model of the Colorado state economy to compare how alternate policies affect the overall economy and the environment by describing how each policy affects overall spending, water use and air pollution. (See the Methodology section on page 27 for more details.)

The results confirm the findings of a raft of earlier studies: implementing a robust clean energy plan will create thousands of good-paying jobs, millions of dollars of economic growth, and significant reductions in pollution—while beginning to limit the costs, risks and liabilities of global warming.[5]

Renewable Energy Benefits Colorado's Economy

Wind, solar energy and clean biomass technologies can provide a clean and sustainable supply of electricity for Colorado. At the same time, these technologies are also an economic development tool that Colorado can use to move its economy forward.

In this report we compare the economic and environmental impacts of Amendment 37 with an expanded renewable energy standard, and with a hypothetical business-as-usual case involving no new renewable energy.

Implementing an accelerated renewable energy standard would greatly benefit Colorado's economy while conserving scare water supplies and reducing air pollution from power plants. Table 1 presents the results of our analysis, showing the economic advantages of a stronger commitment to energy efficiency and renewables. Table 2 shows the factor by which the benefits of an expanded commitment to renewable energy exceed the benefits of Amendment 37.

Employment Gains

Investing in energy efficiency and renewable energy would bring jobs to Colorado. Compared to business as usual, an expanded renewable energy standard would increase employment through the year 2020 by 4,100 person-years, 3,100 more than under Amendment 37. An expanded renewable energy standard would also increase wages paid to workers by a total of $570 million through 2020, $310 million more than Amendment 37. (See Table 3.)

Table 1: Cumulative Net Impact of Amendment 37 and Expanded Renewable Standard (2007-2020)

Measure	Amendment 37	Expanded Renewable Standard
Jobs Created (Person-Years of Employment)	950	4,100
Wages Paid	$250 million	$570 million
Increase in Colorado's Share of Gross Domestic Product	$1.0 billion	$1.9 billion
Conserved Water	11 billion gallons	18 billion gallons
Avoided Global Warming Pollution (CO_2)	26 million metric tons	41 million metric tons
Avoided Smog-Forming NO_x Emissions	35,000 tons	54,000 tons
Avoided Soot-Forming SO_2 Emissions	33,000 tons	49,000 tons
Avoided Mercury Pollution	100 pounds	130 pounds

Note: All impacts are above and beyond the business as usual case. All dollar figures are expressed in 2006 values and are not discounted. For a detailed explanation of the methodology behind the results, see page 27.

Table 2: Increased Positive Impact of an Expanded Renewable Energy Standard vs. Amendment 37

Measure	Expanded Renewables vs. Amendment 37
Jobs Created (Person-Years of Employment)	4.3 times greater
Wages Paid	2.2 times greater
Increase in Colorado's Share of Gross Domestic Product	1.9 times greater
Conserved Water	1.6 times greater
Avoided Pollution in 2020	2.3 times greater

Table 3: Employment and Wage Impact of an Expanded Renewable Energy Standard

Measure	Impact over Business as Usual	Impact over Amendment 37
Cumulative Employment Created (Person-Years, 2007-2020)	4,100	3,100 (4.3 times greater)
Cumulative Wages Paid (2007-2020)	$570 million	$310 million (2.2 times greater)

Renewable energy creates jobs by keeping more dollars in the local economy. Renewable energy helps to replace energy expenditures for fuel or materials produced out of state with labor and materials produced at home.

Clean energy policies also produce more jobs than business as usual because they stimulate industries that are more efficient at creating jobs than other parts of Colorado's economy. For example, wind and solar energy, because they require no fuel, direct more investment into construction than coal- or gas-fired plants. For every $1 million spent on construction in Colorado, 11.7 jobs are created. Alternatively, investing $1 million dollars in coal mining produces 5.2 jobs, while putting $1 million into oil and gas extraction creates only 3.6 jobs.[6]

Figure 1 shows the trajectory of net cumulative job creation due to investment in renewable energy, above and beyond the business as usual case. Similarly, Figure 2 shows the cumulative impact on net wages paid to workers in Colorado. Both figures show that a deeper commitment to renewables leads to greater net employment and wage increases for Colorado. The increases in jobs and wages are driven by changes in spending patterns within the economy as a result of investment in renewable energy. The spike in 2007 is due to the 775 MW of new wind ordered by Xcel Energy in 2006, expected to be operational in 2008.[7] These installations will achieve much of the goal of Amendment 37. After this point, annual installations required to meet the goals of the amendment are relatively small, and net employment impacts gradually decline. Under an expanded renewable energy standard, installations in future years are greater, leading to a higher employment impact.

Figure 1: Cumulative Net Employment Increase under Amendment 37 and an Expanded Renewable Energy Standard (vs. Business-as-Usual)

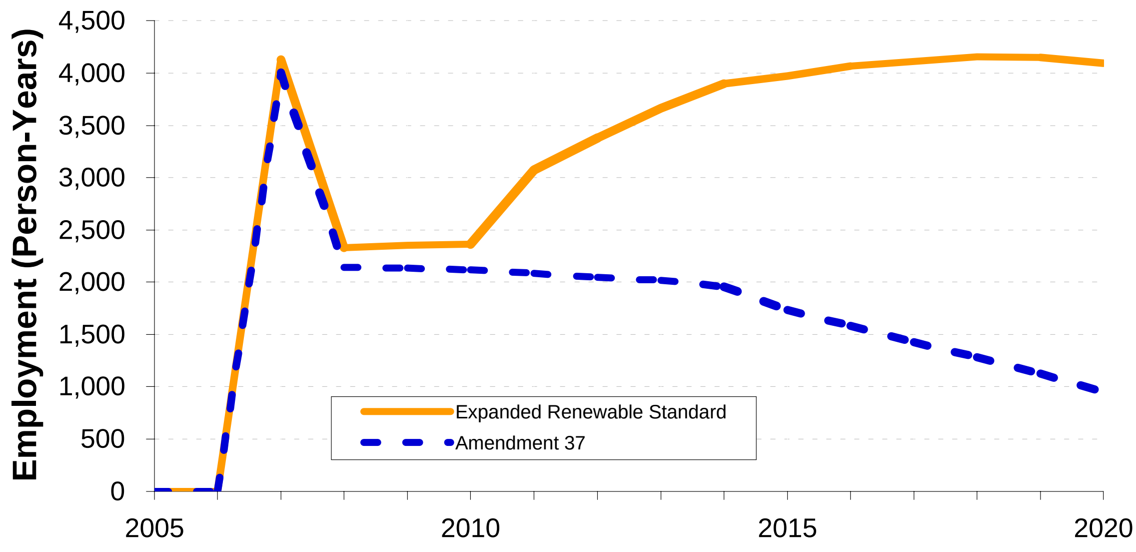
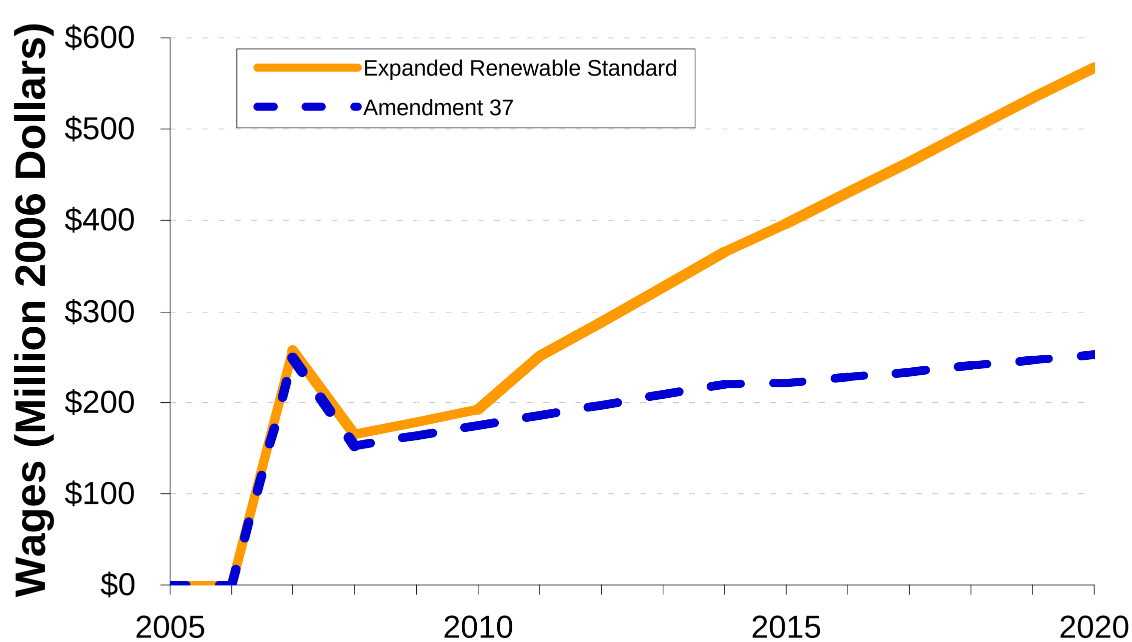


Figure 2: Cumulative Net Wage Increase under Amendment 37 and an Expanded Renewable Energy Standard (vs. Business-as-Usual)



Clean Energy Creates Skilled, High-Paying Jobs

Investment in renewable energy and energy efficiency directly creates quality jobs in manufacturing, construction and building trades, operation and maintenance, and finance.

Manufacturing

Renewable energy systems require highly skilled manufacturing workers who design and build components of wind turbines, solar panels and other technologies.

Much of the work involved in creating a wind farm goes into manufacturing components, which include rotor blades, structural towers, hubs, transmissions, generators and assorted electronic controls. According to a survey of wind energy companies by the Renewable Energy Policy Project (REPP) in 2001, manufacturing 10 MW of wind turbines requires a year of labor from 32 full-time workers.[8]

Colorado is in good position to see employment growth from wind turbine manufacturing. In January 2007, for example, local news media reported that Vestas Wind Systems, the world's largest wind turbine manufacturer, was in negotiations to build a manufacturing facility near Windsor in northern Colorado. If completed, the facility could employ more than 400 workers.[9]

Similarly, much of the work behind solar energy involves manufacturing. Building a photovoltaic panel requires creating cells from silicon and glass, installing wires and other electrical components, and assembling them into a unit. According to a 2002 analysis by University of California-Berkeley Professor Daniel Kammen, by the end of the decade, manufacturing a megawatt of solar photovoltaic panels will require nearly six full-time employees working for a year, given likely improvements in economies of scale and manufacturing technology.[10]

Colorado is home to a variety of solar energy companies. Littleton-based Ascent Solar, for example, is building a manufacturing facility to produce its thin-film photovoltaic systems in Colorado and hopes to ramp-up production of its systems in the years to come.[11]

By increasing local demand for renewable energy and energy efficient products, Colorado could create and enhance opportunities for new companies to locate facilities in Colorado. The state has a well-developed industrial base and access to rail and highway shipping infrastructure—assets that could attract manufacturers interested in tapping into the regional clean energy market. For example, the Spanish wind turbine manufacturing company Gamesa located its U.S. headquarters in Pennsylvania in part because of the state's commitment to renewable energy, as well as its strategic location.[12]

However, to take into account the fact that economic activity for renewable energy is not necessarily tied to Colorado, we assume that 70 percent of all expenses for clean energy programs, including renewable energy manufacturing, construction, financing and ongoing operation and maintenance, will be local. (See Methodology on page 29 for more details.)

Building Trades, Construction and Installation

Installation of renewable energy facilities typically involves local construction firms and general contractors, boosting local economies.

For example, wind farm installation requires local workers. Large wind farms can need up to 300 workers on site during construction. These workers assemble turbines, erect towers, pour concrete, build roads, and lay cable.[13] Steel to

reinforce foundations, gravel and road base, concrete, and supplies for wiring, as well as excavation, transport services and fuel, housing, and food for workers can all benefit local businesses during wind farm construction.

The construction of the Colorado Green wind farm in Lamar supported 400 construction workers, who installed 108 large wind turbines and towers.[14]

Operation and Maintenance

The operation and maintenance needs of a wind farm or a biomass facility create permanent, high-quality local jobs ranging from servicing turbines to accounting.

Wind farms need staff to operate and regularly service the turbines throughout their roughly 30-year lifetimes. A survey of large wind farms in Texas found that every 100 MW of capacity requires six full-time employees to operate, monitor, and service the turbines.[15]

The Colorado Green wind farm in Lamar, a 162 MW facility, created 14 full time, well-paying operation and maintenance jobs in Prowers County.[16]

Spillover Effects

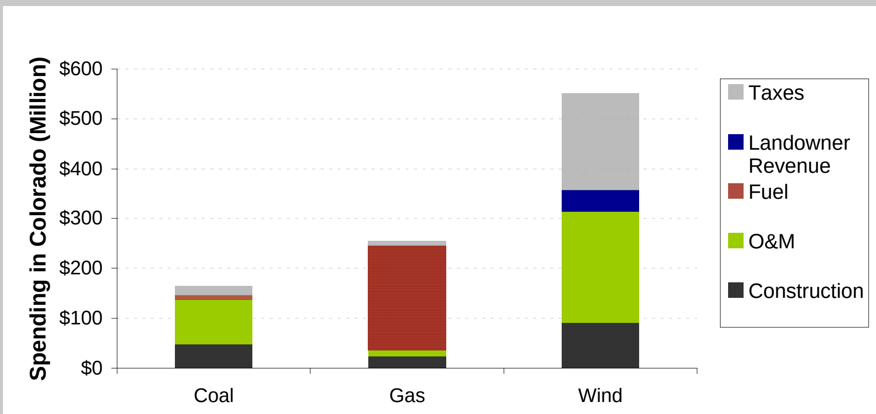
Each dollar spent on renewable energy creates impacts that ripple outward through the local economy, extending far beyond the direct creation of jobs at energy facilities.

For example, workers at a manufacturing plant need raw materials and equipment. Their work in assembling turbines supports jobs in equipment manufacturing and component supply. Contractors at a construction site need concrete and heavy equipment, and their work supports additional jobs supplying these needs. In addition to these indirect jobs, workers spend much of their wages in the local economy, purchasing goods and services like groceries and housing and supporting additional workers.

RENEWABLE ENERGY FACILITIES HAVE LARGER DIRECT ECONOMIC IMPACT THAN COAL OR GAS-FIRED POWER PLANTS

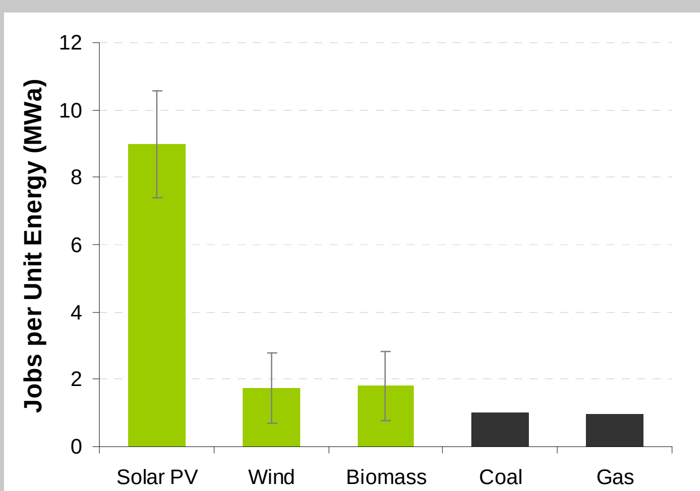
The National Renewable Energy Lab found that a wind farm in Colorado has more than three times the direct economic impact to the state of an equivalent coal-fired power plant, and more than twice the impact of an equivalent gas-fired power plant. (See Figure 3.) Wind energy directs more energy dollars into the local economy for construction, operation and maintenance, landowner revenue, and taxes. In contrast, the primary advantage of gas-fired plants for the local economy is that they can support Colorado's natural gas extraction industry, while coal-fired power has a smaller overall connection to the local economy.

Figure 3: Direct Economic Impact of Wind, Gas and Coal Power Plants in Colorado (on an Energy-Equivalent Basis)[17]



Similarly, a variety of studies confirm that renewable energy generates more jobs per unit energy produced than fossil-fuel technologies on an absolute basis—not taking into account the amount of money that stays within the local economy.[18] (See Figure 4, which presents the total number of direct jobs created per unit of energy for selected renewable and fossil technologies, including manufacturing, installation, fuel extraction, and operation and maintenance.)

Figure 4: Jobs per Unit of Energy from Renewable and Fossil Technologies, U.S.[19]



Renewable Energy Can Stimulate Rural Economies

Local Jobs

Renewable energy installation can create jobs in rural parts of the state. Wind farms in particular are often located in places where local economies depend on farming or resource extraction. Local jobs include construction and facility installation, operation and maintenance of the facility after it is constructed, and jobs induced by the additional money the workers spend on locally obtained goods and services.

The Colorado Green wind farm is an excellent example. The 162 MW facility attracted a $200 million investment to Lamar and supported 400 construction workers during installation and 14 permanent and full-time operation and maintenance jobs.[20]

Landowner Royalties

Rural landowners who lease their property for a wind facility can enjoy an additional source of income. Unlike the income from a typical harvest or livestock sale, payments from wind energy are steady and year-round. The Union of Concerned Scientists estimates a farmer or rancher with good wind resources could increase the economic productivity of his or her land by 30-100 percent.[21]

Lease terms vary, but they typically represent 2.5 percent of gross revenue from electricity sales.[22] Assuming a contract price for electricity generated from wind power of 3.5 ¢/kWh, a single 1.5 MW turbine with a 30 percent capacity factor would bring the landowner $3,500 each year. In the case of land owned by a local government, leasing income could be funneled into local schools and services.

Under an expanded renewable energy standard, electricity produced by wind farms in Colorado through 2020 could supplement rural landowner income by about $50 million, benefiting farmers, other private landowners, and local and state government.[23] These payments would be about 60 percent more than those created by Amendment 37.

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NREL

Local Tax Income

Renewable energy equipment will raise the property tax base of a county, creating a new revenue source for education and other local government services. For example, the Colorado Green wind farm in Lamar raised the property tax base in Prowers County by $32 million in one year, increasing annual tax revenue by one-third.[24] The leaders of Prowers County decided to distribute some of that revenue back to residents, awarding a property tax reduction of 12 mills.[25]

Expanding Colorado's renewable energy standard would funnel $400 million into local government coffers through 2020, 70 percent more than under Amendment 37 alone.[26]

Wind power has several advantages over coal- and gas-fired power plants when it comes to contributing to the economic health of local governments. First, Colorado's wind energy resources are distributed across a wide area of the state, especially on the eastern plains. Central station power plants, in contrast, are concentrated on smaller areas of land and can only benefit a handful of communities.

Coal-fired power plants also pay a proportionally smaller share in property taxes than renewable energy, because they require less land and less capital investment per unit of energy produced (with a greater share of cost for ongoing fuel expenses).[27] Colorado communities also have a history of negotiating deals with energy companies to waive a fraction of the tax liability in return for locating the plant in a specific area.[28]

The National Renewable Energy Laboratory calculates that, on an energy equivalent basis, wind farms in Colorado provide more than 10 times the tax income of a coal-fired power plant, and more than 20 times the tax income of a gas-fired plant.[29]

Energy Crop Production

Using tree trimmings for energy, or specifically growing a crop for energy on a plot of land, can also help advance the economies of rural parts of Colorado.

For example, the Oak Ridge National Laboratory (ORNL) estimates that planting and harvesting 188 million dry tons of switchgrass, an energy crop, would increase total U.S. farm income by $6 billion.[30] ORNL also estimates that Colorado has the potential to produce over 5 million dry tons of biomass resources from crop residues and switchgrass planting per year.[31]

Economic Output

Investments in renewable energy, dollar for dollar, produce a greater net benefit for Colorado's economy than traditional technologies.

In addition to creating jobs and increasing wages paid in Colorado, expanded renewable energy development would increase the state's overall economic output. Increasing Colorado's renewable energy standard would increase Colorado's share of gross domestic product (GDP) by a cumulative total of $1.9 billion through 2020, nearly twice the impact of Amendment 37 alone. Figure 5 shows the cumulative impact on GDP over time, in constant 2006 dollars.

GDP share is the traditional measure of basic state economic activity. It is a measure of the goods and services produced within the state in a given year, minus imports. Renewable energy policies improve GDP because they increase the amount of money kept within the local economy. For example, one dollar invested in Colorado's construction sector creates $0.735 worth of economic output. Alternatively, one dollar invested in natural gas distribution creates $0.495 worth of output.[32]

Reduced Water Usage

Renewable energy has the additional benefit of conserving water. This benefit is especially important given Colorado's relatively dry and arid climate, the growing demand placed on water supplies by a growing population, and the probability that global warming will continue to reduce Colorado's winter snowpack.[33]

Traditional power plants depend heavily on a constant supply of water to produce steam and provide cooling.[34] Some cooling water is released to the atmosphere, irreversibly consumed and thus becoming unavailable for other uses. In contrast, renewable energy technologies use very little water (with the exception of some solar thermal and biomass technologies that generate steam to move a turbine). For example, water use for a central utility solar PV system is limited to that required to periodically wash dust off of the solar panels. Table 4 shows the consumptive water use of different types of energy systems.[35]

Assuming that an average new fossil-fueled plant in Colorado would consume 300 gallons of water per MWh produced, an expanded renewable energy standard would conserve 18 billion gallons of water between 2007 and 2020, 60 percent more than under Amendment 37.

To put that in perspective, a typical Coloradan uses around 200 gallons per day.[36] In other words, through 2020 renewable energy could save enough water to meet the needs of the City of Denver for a half-year, or enough to fill Cherry Creek Reservoir more than twice.[37] Figure 6 shows the projected annual water savings.

Water is a valuable commodity in Colorado. Recently, rights to one unit of water per year from the Big Thompson River have been selling for about $10,700.[38] Water rights from this river are representative of the resources on the Front Range.[39] In a wet year, one unit is about an acre-foot of water, or 326,000 gallons. During a drought, a unit can be one-third that amount.[40]

Figure 5: Cumulative Net Increase in Colorado's Share of Gross Domestic Product due to Renewable Energy Investment

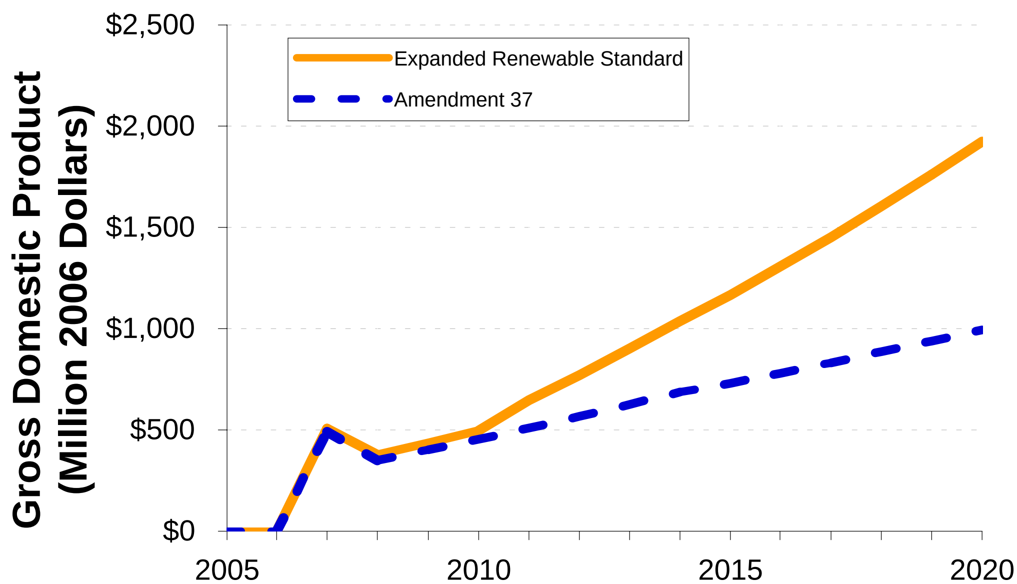
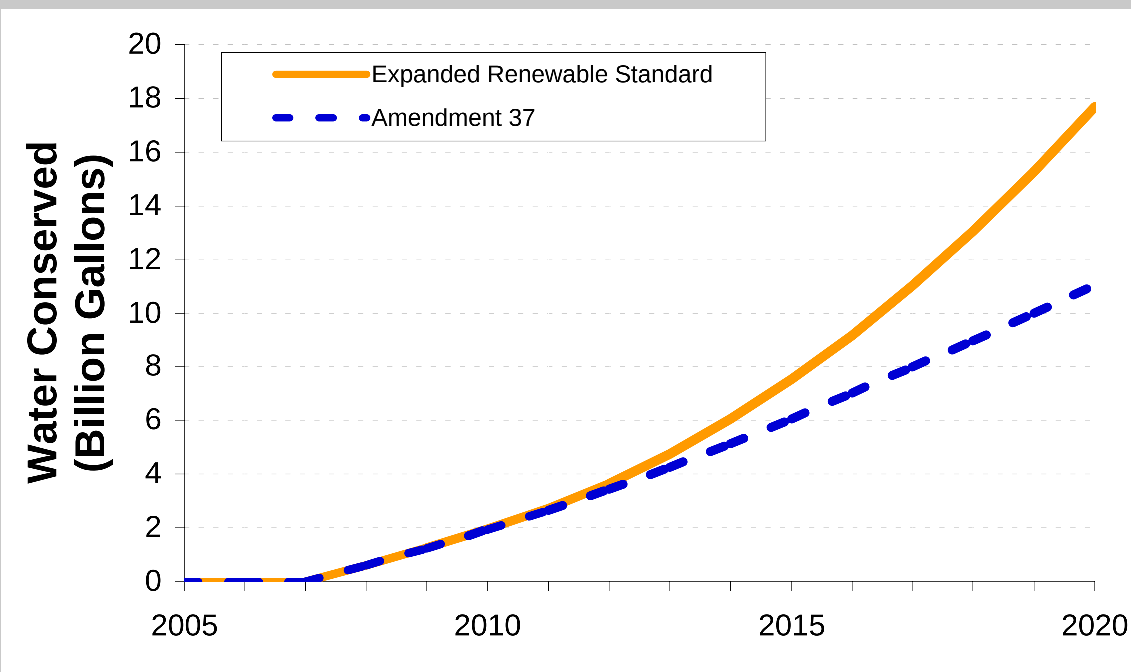


Table 4: Consumptive Water Requirements of Energy Generation Technologies

Energy Technology	**Water Consumption (gallons per MWh)**
Coal-fired simple cycle power plant, once-through cooling	290 to 320
Coal-fired simple cycle power plant, re-circulating cooling system	690
Natural gas combined cycle power plant, once-through cooling	100
Natural gas combined cycle power plant, re-circulating cooling system	180
Nuclear power	820
Solar PV, residential	Negligible
Solar PV, central utility	25
Solar Thermal, Luz System	1,100
Solar Thermal, Stirling Engine	Negligible
Wind	Negligible
Biomass, once-through cooling	350
Geothermal (water is typically drawn from high-mineral content areas deep underground and is not suitable for other uses)	0 to 1,000

Note: This table presents water consumption requirements as opposed to water withdrawal requirements. Once-through cooling systems require more water withdrawals, but return more of the withdrawals to a water body than a re-circulating system.

Figure 6: Estimated Cumulative Water Savings from Renewable Energy Use



At the above price, the right to the water that would be saved by an expanded renewable energy standard in the year 2020 would be worth between $70 and $220 million (2006 dollars); 2.3 times more than the value of water saved by Amendment 37 in that year.

Reduced Pollution

In addition to economic benefits and monetary savings, investing in renewable energy would reduce global warming and help create a cleaner, healthier future for Colorado. Expanding Colorado's renewable energy standard would significantly reduce emissions of carbon dioxide, the leading cause of global warming, as well as speed progress in reducing soot, smog and mercury pollution, which damage public health. Table 5 summarizes the pollution prevention impacts of an expanded renewable energy standard compared to Amendment 37.

Reduced Global Warming Pollution

Global warming poses a serious challenge to Colorado's future. Scientists have concluded that pollution caused by human activity is driving a dramatic warming trend now apparent across the globe.

The consensus view of the scientific community is that most of the global warming that has occurred is directly due to human activities, particularly burning fossil fuels. Fossil fuel combustion releases carbon dioxide, which traps radiation reflected from the earth's surface that normally would escape back to space (much like a blanket). Carbon dioxide levels in the atmosphere are now increasing faster than at any time in the last 20,000 years, and are likely higher now than at any point in the last 20 million years.[41]

Average temperatures worldwide have risen by about 1.4° F in the past century and now are increasing at a rate of about 0.36° F per decade.[42] The 10 warmest years in the global record have all occurred since 1990, and 2006 was the warmest year to date in the lower 48 states.[43]

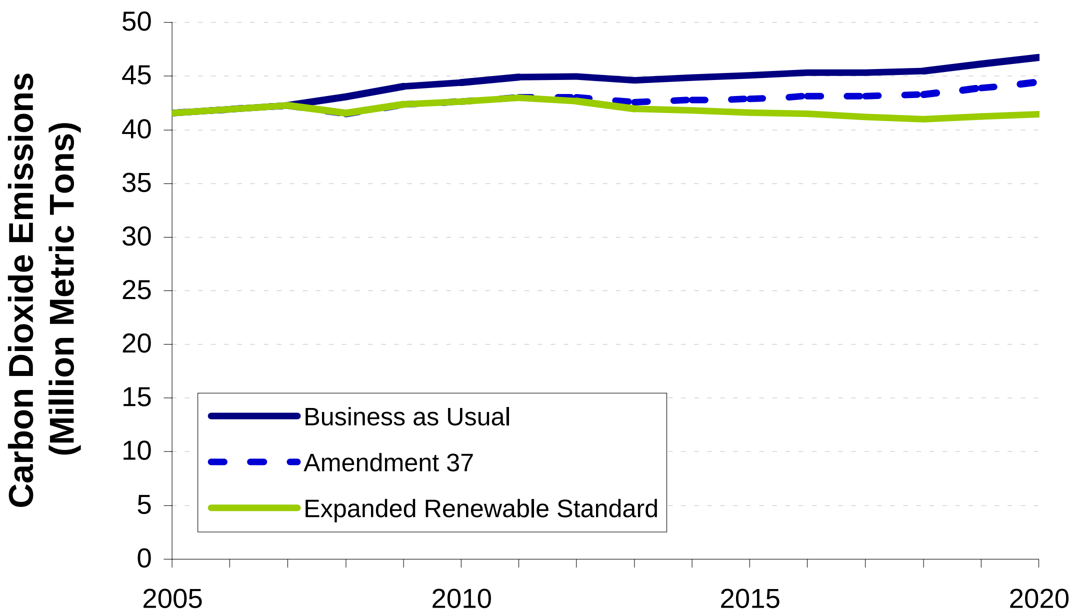
Already, warming-induced changes are visible in Colorado and the West. Measured at more than 200 mountain sites over the last 50 years (especially those at lower elevations), more winter precipitation is falling as rain and less as snow.[44] Snowpack levels are declining.[45] Snowmelt is happening earlier in the year—with peak runoff happening up to 30 days earlier in some cases.[46] Wildfire seasons are becoming longer and more intense.[47] Worldwide in the last half of the 20th century, 1,700 plant, animal and insect species shifted toward the earth's poles at an average rate of about 4 miles per decade.[48]

Table 5: Cumulative Pollution Prevention Impact of Renewable Energy vs. Business as Usual (2007-2020)

Measure	Amendment 37	Expanded Renewable Energy Standard
Avoided Global Warming Pollution (CO_2)	26 million metric tons	41 million metric tons
Avoided Smog-Forming NO_x Emissions	35,000 tons	54,000 tons
Avoided Soot-Forming SO_2 Emissions	33,000 tons	49,000 tons
Avoided Mercury Pollution	100 pounds	130 pounds

In the West, scientists predict that annual temperatures could be 4° to 13° F warmer than today by the year 2100.[49] Warming on such a scale would have serious consequences for Colorado and the world. Colorado could face further reduced snowpack, shorter and less attractive ski seasons, water shortages, longer and more intense wildfire seasons, and a significant change in the range of plant and animal species across the state. Worldwide, global warming could create hundreds of millions of refugees fleeing flooding or drought and permanently reduce global

Figure 7: Effect of Renewable Energy on Global Warming Pollution from Electricity Generation in Colorado



economic output by 20 percent per year, or roughly $7 trillion annually.[50]

The government of the United Kingdom recently estimated that each metric ton of carbon dioxide released causes a minimum of $160 worth of damage, worldwide.[51] Left unchecked, global warming will impose serious costs on Colorado and the U.S. as a whole.

On average, each megawatt-hour of electricity generated in Colorado produces about 1,825 pounds of carbon dioxide.[52] Without action, Colorado's electricity sector will emit increasing amounts of carbon dioxide pollution into the future.

Expanding Colorado's renewable energy standard would reduce carbon dioxide emissions from electricity generation in Colorado by about 11 percent in 2020—preventing 5.3 million metric tons of carbon dioxide emissions in that year. The expanded renewable energy standard would be 2.3 times as effective as Amendment 37 in preventing global warming pollution in Colorado in 2020. (See Figure 7.)

Emissions cuts on this scale would be the first steps for Colorado on the road to doing its fair share to mitigate the worst effects of global warming—which will require cuts in carbon dioxide emissions on the order of 50 percent worldwide by 2050 (and up to 80 percent in the U.S., which shoulders a larger responsibility as the world's largest emitter).[53]

Colorado has additional policy options that can further reduce global warming emissions, including programs to increase energy efficiency. An effective suite of efficiency measures could prevent the need for new power plants in Colorado and help enable the retirement of old coal-fired power plants that are a major part of Colorado's contribution to global warming. Moreover, energy efficiency is the cheapest energy option available for the state.

Reduced Soot and Smog

Coal and natural gas-fired power plants emit air pollution. For every megawatt-hour of electricity generated, the average Colorado power plant emits 2.7 pounds of soot-forming sulfur dioxide and 3.1 pounds of smog-forming nitrogen oxides.[54] Partially because of this pollution, the Denver metropolitan area is on the verge of violating federal air quality standards for smog.[55]

Sulfur dioxide emissions from coal-fired power plants form fine soot particles in the atmosphere. When inhaled, these particles become lodged deep in the lungs where they cause a variety of health problems, including asthma, bronchitis, lung cancer and heart attacks.[56] Soot pollution from power plants is responsible for significant harm to public health in Colorado. According to a study by Abt Associates, a frequent consultant to the U.S. EPA, soot in Colorado cuts short the lives of 115 people, and causes more than 3,600 asthma attacks and more than 21,000 missed work days due to respiratory illness annually.[57]

Fossil-fueled power plants also emit nitrogen dioxide, one of the primary ingredients in smog.


Andy Olsen, Istockphoto.com

Smog makes lung tissues more sensitive to allergens and less able to ward off infections.[58] It scars airway tissues.[59] Children exposed to smog develop lungs with less flexibility and capacity than normal. During high smog days, otherwise healthy people who exercise can't breathe normally.[60] Over time, smog exposure can lead to asthma, bronchitis, emphysema and other respiratory problems.[61]

Health problems imposed by soot and smog have serious economic consequences for Colorado. Beyond the loss of priceless years of healthy life, an unhealthy workforce is less productive.

Soot and smog pollution from power plants are projected to decrease in the coming years because of implementation of the Clean Air Act. However, increased use of renewable energy will reduce soot and smog emissions even further:

- By 2020, an expanded renewable energy standard would reduce smog-forming nitrogen dioxide emissions by more than 6,000 tons per year less than projected levels, a decrease of about 11 percent.
- It would also avoid 5,000 tons of soot-forming sulfur dioxide emissions, also a reduction of about 11 percent less than projected levels.
- These reductions would be 2.3 times greater than under Amendment 37 alone.

Reduced Mercury Deposition

Mercury emissions from coal-fired power plants and other industrial sources are making the fish in our lakes, rivers and streams unsafe to eat. Burning coal releases mercury into the air that eventually contaminates rivers and lakes, where bacteria convert it to a highly toxic form that bioaccumulates in fish.

In early 2007, two new studies of mercury deposition in the Northeast confirm that U.S. coal-fired power plants are the chief cause of mercury contamination "hot spots."[62] The studies show that "mercury deposition is five times higher than previously estimated by EPA" in the area surrounding a coal plant in southern New Hampshire.[63] Dr. Thomas Holsen of Clarkson University and one of the study authors remarked that "… a significant fraction of the mercury emitted from coal-fired power plants in the U.S. is deposited in the area surrounding the plants." Dr. Charles Driscoll, another study author, noted that "biological mercury hotspots occur and … mercury emissions from sources in the U.S., as opposed to China and other countries overseas, are the leading cause."

Mercury is a neurotoxin that is particularly damaging to the developing brain. In early 2004, EPA scientists estimated that one in six women of childbearing age in the U.S. has levels of mercury in her blood that are sufficiently high to put her baby at risk of learning disabilities, developmental delays and problems with fine motor coordination, among other health impacts.[64]

In 2004, Colorado's coal-fired power plants emitted 516 pounds of mercury.[65] This pollution has contributed to elevated levels of mercury in the fish in Colorado's waters. The state has issued fish consumption advisories for more than 17,000 acres of Colorado lakes contaminated with mercury, or 12 percent of all lake area.[66]

Early in 2007, Governor Ritter announced a new state rule that would reduce mercury pollution from Colorado's power plants by 80 percent by 2014, increasing to 90 percent by 2018.[67] This rule will significantly reduce Colorado's mercury emissions. However, an expanded renewable energy standard would reduce them even further, preventing an additional 130 pounds of mercury emissions through 2020, while Amendment 37 would prevent on the order of 100 pounds.[68]

Colorado Has Vast Renewable Energy Resources

Colorado has a vast and endlessly replenishing reserve of renewable energy resources, including wind, sunlight and biomass. Together, these resources are more than enough to support an expanded renewable energy standard.

According to *The Renewable Energy Atlas of the West*, renewable resources in Colorado—including wind, biomass and solar power—could generate 14 times as much electricity as the state used in 2005. (See Table 6.)

WIND

Wind energy is coming into its own as a reliable part of Colorado's electricity system.

The inclusion of wind farms (like the Colorado Green Wind Farm in Lamar) in Xcel's generation portfolio has benefited Colorado energy consumers. Wind has helped by providing a hedge against natural gas price spikes that have driven up electricity and heating prices in recent years.

Whenever wind is available, the highest-cost natural gas generators producing power at the time are turned down, or turned off. Since wind has no fuel cost, once wind turbines are installed, consumers can know exactly how much wind will cost for the life of the turbines.

Xcel Energy determined that in 2005, the cost stability of wind energy on its system saved its customers a net of $9.75 million.[69] According to the Interwest Energy Alliance, Coloradans will save more than $250 million over the next two decades because of the wind farms on Xcel's network as of summer 2006.[70]

Colorado has vast wind energy resource potential. One estimate places Colorado's technical wind energy potential at more than 600,000 GWh per year, or 12 times more electricity than the state consumed in 2005.[71]

Most of Colorado's wind resource can be found on the Eastern Plains, particularly north of Fort Collins, east of Colorado Springs, and south of Trinidad. (See Figure 9.) These areas also tend to be rural parts of the state, where the addition of wind energy infrastructure can have a big economic impact.

Even though the wind doesn't necessarily blow all the time, wind power can make a valuable contribution to Colorado's overall electricity grid. Nations such as Denmark have shown that it is possible to obtain 20 percent of their electricity supplies from wind (and much more at certain times and places). In early 2006, a group of the nation's largest utility companies found that at wind penetration levels of up to 20 percent, "system stability in response to a major plant or line outage can actually be improved by the addition of wind generation"; the cost of integrating wind energy into a typical utility system is affordable; and wind energy does not

Table 6: Colorado's Renewable Energy Resources[72]

Energy Source	Electricity Generation Potential (GWh / year)	Percent of Colorado's 2005 Total Energy Demand
Wind	601,000	1,240%
Solar PV (0.15% of Colorado's Land)	83,000	170%
Biomass	4,000	8%
Total	**687,000**	**1,420%**

Amendment 37 Compared to an Expanded Renewable Energy Standard

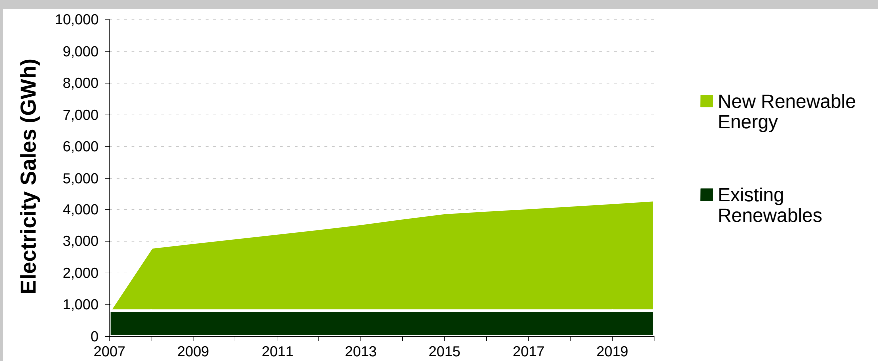
Under Amendment 37, Colorado's top utility companies must provide a percentage of their retail electricity sales from renewable resources—3 percent by 2007, increasing to 10 percent by 2015 and thereafter. The amendment applies to investor-owned utilities Xcel and Aquila; the municipal utilities of Colorado Springs, Fort Collins and Longmont; and one out of three of the state's eligible cooperative utilities. (The other two eligible cooperative utilities have opted out of the requirement.) We estimate that the amendment will apply to 75 percent of generation in the state.

To promote development of Colorado renewable resources, Amendment 37 credits every kilowatt-hour (kWh) of renewable energy generated in state as if it were 1.25 kWh. As a result, Amendment 37 will achieve renewable energy generation equivalent to about 5 percent of the state's total electricity demand by 2020. (If future revisions to the law re-formulate this incentive to give in-state generation 100 percent credit and credit out-of-state generation less, or to increase the required percentage of renewable energy, it could achieve higher penetration levels.)

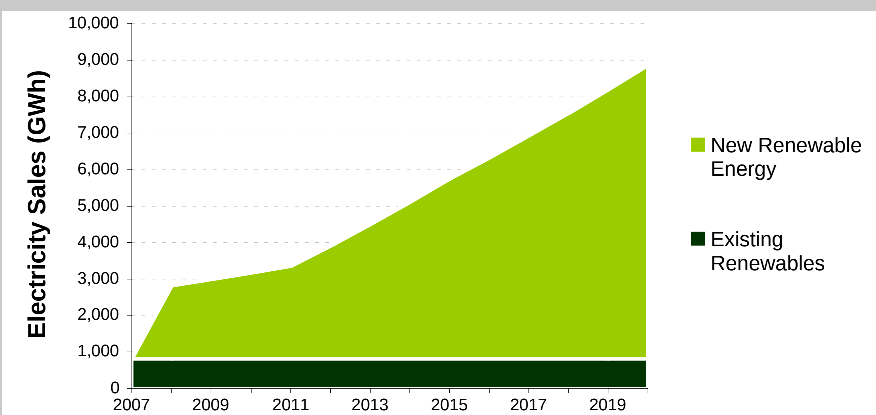
Xcel Energy has demonstrated that the targets of Amendment 37 are easily within reach. During the summer of 2006, Xcel signed contracts for an additional 775 MW of wind energy, putting the utility on track to meet the goals of Amendment 37 eight years early.[73] (See Figure 8A.)

Colorado's utilities could achieve even greater renewable energy penetration in the next decade. Under an expanded renewable energy standard of 20 percent by 2020 for Colorado's investor-owned utilities, plus a supplemental standard of 10 percent by 2020 for the state's cooperative electricity companies and eligible municipalities with more than 40,000 customers (with continuation of the in-state generation credit), actual renewable energy generation could reach about 11.5 percent of total statewide electricity sales by 2020. (See Figure 8B.)

Figure 8: Renewable Energy Deployment under Amendment 37 (A) and an Expanded Renewable Energy Standard (B)

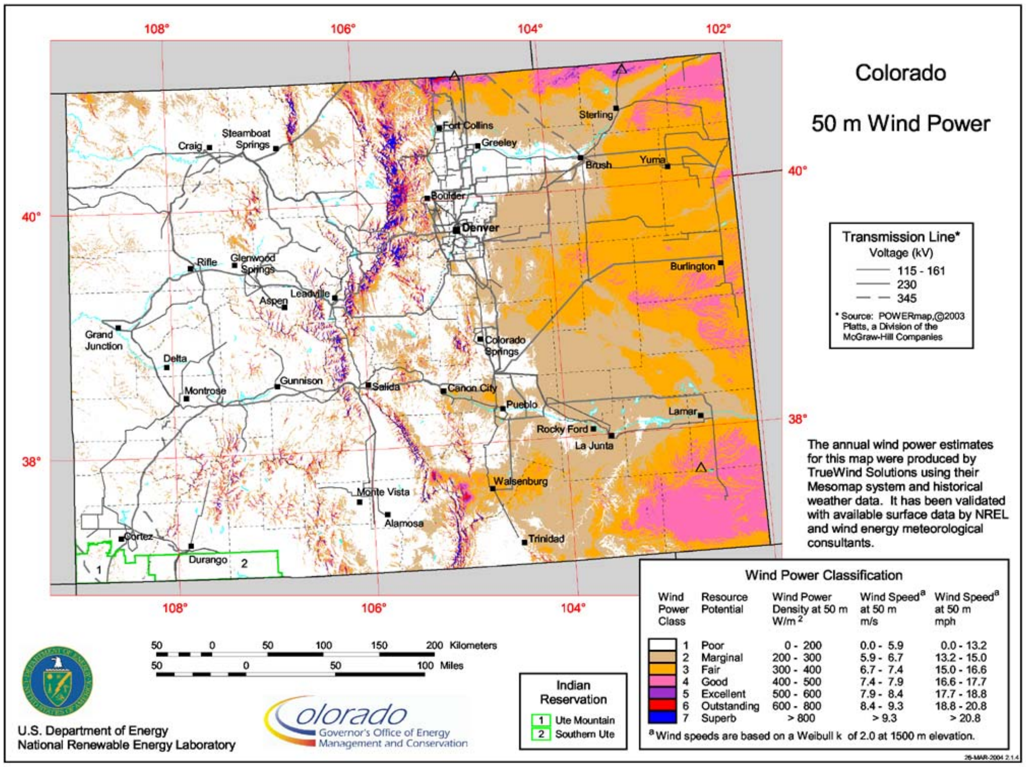


A



B

Figure 9: Colorado's Wind Energy Resources



require backup generation.[74] And a recent study undertaken in Minnesota found that utilities can obtain up to one-quarter of their electricity from wind without harming grid reliability, and with only minor costs for absorbing the intermittent power.[75]

Solar

Colorado also has significant solar energy resource potential, with over 300 days of sunshine per year. According to the *Renewable Energy Atlas of the West*, Solar photovoltaic panels occupying just 0.15 percent of Colorado's land area could generate 83,000 GWh per year, nearly twice the amount of electricity that Colorado used in 2005.[76]

The simplicity of photovoltaic panels makes them easy to install on rooftops throughout urban areas; they are the only electric generators without moving parts, and like wind they have no fuel supply to maintain.

The economics of solar photovoltaic panels (PV) as a direct electricity generation source are not yet as favorable as the economics of wind, but that is rapidly changing. As with wind power, the cost of solar PV has dropped dramatically in recent years—over the last two decades, the cost of solar panels has declined from about $20 per Watt to as low as $3.50 per Watt today.[77] (However, due to rapidly expanding demand, manufacturing capacities are strained and prices for silicon wafers rose about 10 percent in the first half of 2006.[78] Further investment in solar technology and manufacturing capacity will be required to expand the industry and eventually bring prices back down—as is happening in states that are actively expanding their solar markets.[79])

Moreover, residential and commercial PV provides unique economic value because of its status as a distributed resource—meaning that PV installations can reduce the need for additional investments in electricity transmission and distribution infrastructure. PV panels also generate electricity during the peak hours of

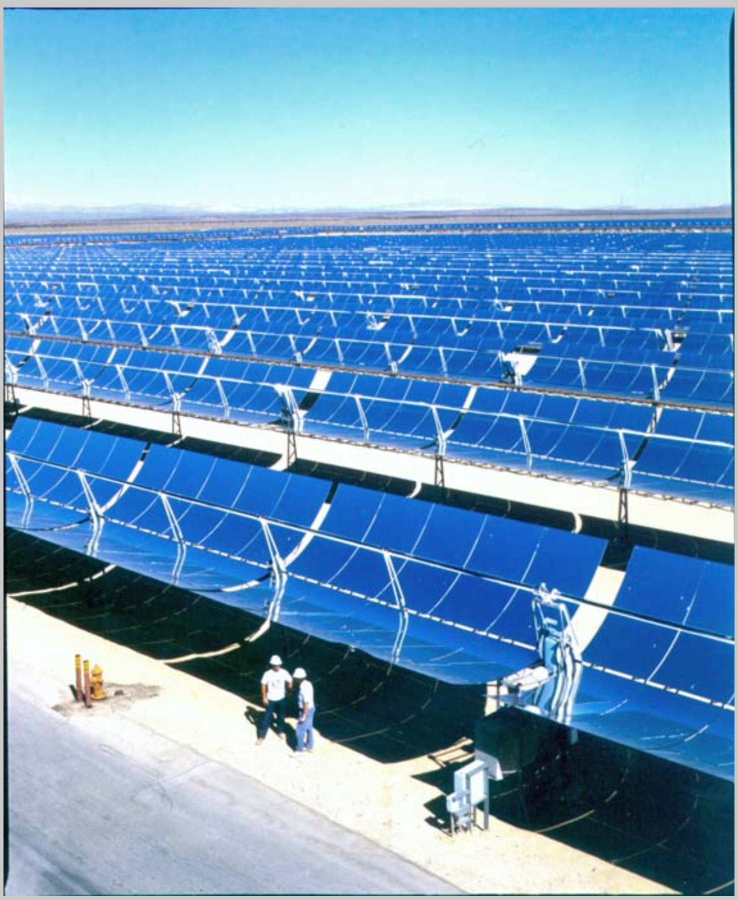
Concentrating Solar Thermal Power

Concentrating solar thermal power is on the brink of commercial viability, and could provide Colorado with another clean source of energy in the future.

Solar power towers with thermal storage can store heat collected from sunlight during the day, to generate electricity during cloudy weather or even at night—an effective power source that is clean, sustainable and produces zero global warming pollution.[80] Stirling dish solar systems are able to capture and transform the heat of the sun into electricity at twice the efficiency of any other solar technology. And solar trough systems have been refined to the point where companies are installing commercial facilities in the Nevada desert.

New solar trough plants will be able to operate with little to no backup from natural gas and produce power at competitive costs. With the installation of the first 1,000 to 3,000 MW of capacity, experts predict that experience and economies of scale will lower the cost of power from these facilities to as low as 5 cents per kWh—cheaper than coal-fired power with carbon storage, and competitive with conventional coal.[81]

Solargenix Energy is building a solar trough power plant in Boulder City, Nevada, scheduled for operation in early 2007, supported by Nevada's renewable energy standard.[82] Solargenix is considering the addition of thermal storage technology within the next few years.[83] Stirling Energy Systems is building two large Stirling solar dish power plants in the desert southwest to supply energy to California.[84] One 300 MW power plant, consisting of 12,000 Stirling dishes to be built in Arizona, will supply energy to San Diego Gas and Electric. The other plant, a 500 MW facility with 20,000 Stirling dishes, will be built in the Mojave Desert near Los Angeles, supplying energy to Southern California Edison. The facilities will help the two utility companies meet California's renewable energy standard.



Solar thermal technology could rapidly increase in importance as a source of electricity in the U.S. The materials needed to produce a power plant are fairly commonplace, including glass, steel, salt, concrete and conventional steam turbines. Sandia National Laboratory estimates that a handful of companies implementing the technologies could install 20 GW of solar thermal capacity in the southwestern U.S. by 2020.[85]

We are not aware of an official estimate of Colorado's solar thermal energy potential, but it is likely substantial. For example, Nevada alone, excluding sensitive areas and land with a slope greater than 1 percent, has the potential for 1,700 GW of solar energy.[86]

sunlight, often when the cost to generate additional electricity is the highest. Because of these characteristics, solar panels benefit all users of the electricity grid—not just the owners of the panels. For example, the city utility of Austin, Texas estimates that solar power is worth 10.4 to 11.7 cents per kWh when added to its system.[87]

Biomass

Colorado also has significant potential to generate electricity using clean biomass materials, like switchgrass and crop residues. According to the *Renewable Energy Atlas of the West*, Colorado could produce enough biomass to generate 4,000 GWh of electricity per year, or about 8 percent of current electricity consumption in the state.[88] Landfill methane could also offer a significant energy contribution.

There are several ways that biomass material can be turned into usable energy, but only methods that minimize toxic emissions should be considered renewable.[89]

Methodology

Environment Colorado Research & Policy Center developed a Colorado-specific energy and economic model to project the economic and pollution reduction impacts of improving energy efficiency and deploying renewable energy technologies. The model employs input-output economic principles and is based on statistics that describe the production and exchange of goods and services within the various sectors of the Colorado economy, as provided by the Minnesota IMPLAN Group, Inc. (MIG), with all dollar results reported as the equivalent of 2006 values.[90] The results are generally consistent with a large number of state-level studies that have been carried out previously.[91] This approach allows a meaningful comparison of baseline projections of energy consumption and prices with changes driven by clean energy policies.[92]

Establishing the Default Path

We first established a baseline forecast for energy development in Colorado from 2007 to 2020. This default path served as the point of comparison with Amendment 37 and with an expanded renewable energy standard.

The projections for future energy demand in Colorado come from the Colorado Energy Forum, an educational non-profit established by a former director of the Colorado Public Utilities Commission.[93]

Forecasts for electricity prices, natural gas consumption, coal consumption, power plant heat rates and power plant environmental performance (in terms of per kWh emission factors) were established using the most recent statistics from the U.S. Energy Information Administration (EIA) for Colorado's electricity sector, forecast to 2020 using the trajectory set in the regional tables of EIA's *Annual Energy Outlook 2006*.[94] For example, EIA forecasts a 0.9 percent annual growth rate for coal consumption in the Southwest Power Pool region, which, when applied to Colorado, yields a forecast for the quantity of coal the state will consume in the future. In terms of environmental performance, we calculate an average per kWh emission forecast for generation in Colorado. EIA forecasts include an estimate of reduced air pollution levels as the Clean Air Act is further implemented.

Other analysts have noted that EIA forecasts for energy prices, especially natural gas, are likely underestimated.[95] Higher prices for energy under the business-as-usual scenario would likely increase the economic benefits of renewable energy, especially by protecting consumers from higher rates.

Macroeconomic forecasts for Colorado under the business as usual path, including GSP, employment and wages, were calculated from EIA's *Annual Energy Outlook 2006*, scaled to Colorado using state and U.S. economic forecasts published by Woods and Poole Economics, Inc.[96]

Describing the Impact of Amendment 37

We modeled the impact of Amendment 37 to determine the amount of renewable energy required. Key assumptions include:

- Utilities will comply with the law using 100 percent in-state generation, with every kWh of electricity credited at 1.25 kWh for the purposes of determining compliance.
- The standard applies to Xcel, Aquila, Colorado Springs, Longmont, Fort Collins, and Holy Cross distribution cooperative. We estimated future sales of these entities at 75 percent of the base case electricity forecast described above, based on the 2004 sales statistics for these utilities.[97]
- In 2006, Colorado begins at a baseline of existing renewable energy sources producing 810 GWh.[98] Since this infrastructure already exists, we did not

consider it in the economic impact modeling.
- During the summer of 2006, Xcel signed contracts for an additional 775 MW of wind energy.[99] We assume that these facilities will begin contributing electricity in 2008 and will supply about 2,000 GWh per year.
- Utilities governed by the standard will reach 6 percent renewable energy in 2011 and 10 percent renewable energy in 2015, continuing at 10 percent in years thereafter, with linear growth between these milestones. (See Figure 8A on page 23.)
- The standard will be met with 96 percent wind energy and 4 percent solar energy.

Describing the Expanded Renewable Energy Standard

We also modeled the impact of an expanded renewable energy standard with the following characteristics and assumptions:

- In 2006, Colorado begins at a baseline of existing renewable energy sources producing 810 GWh. Since this infrastructure already exists, we did not consider it in the economic impact modeling. We additionally assume that the 775 MW of wind acquired by Xcel in the summer of 2006 will begin supplying electricity in 2008, at 2,000 GWh per year.
- The in-state generation incentive in Amendment 37 will continue to apply, and all utilities will comply with the law using 100 percent in-state generation, credited at 1.25 times more than actual generation.
- The renewable energy standard for Xcel and Aquila (59.5 percent of forecast demand) will be 3 percent in 2008, 10 percent in 2011 and 20 percent in 2020, with even growth in intermediate years (beginning with Xcel's 775 MW of wind in 2008).
- The standard for cooperative electricity companies and and municipalities with more than 40,000 customers (36.6 percent of forecast demand) will be 1 percent in 2008, 3 percent in 2011, 6 percent in 2015 and 10 percent in 2020. (See Figure 8B on page 23.)
- The standard will be met with 96 percent wind energy and 4 percent solar energy.
- Capital costs and operation, maintenance and fuel costs of each technology will decline as the technologies mature.[100]

Modeling the Environmental Impact of Renewable Energy Development in Colorado

Reduced Pollution

We calculate the amount of pollution reduction based on the amount of displaced conventional generation and the per kWh baseline emission forecast per EIA's *Annual Energy Outlook 2006*, described above.

Reduced Water Usage

We assume that conventional electricity generation in Colorado requires 300 gallons per MWh, as described in the text of the report. We assume that renewable energy has negligible water use, and calculate water savings based on the amount of displaced conventional generation.

Modeling the Economic Impact of Renewable Energy Development in Colorado

Renewable energy deployment will require a change in technology investments, energy prices, and energy expenditures. We estimated these expenditures for the Amendment 37 case and for the expanded renewable energy standard case based on the capital, operations, maintenance and fuel costs for renewable energy technologies. We then mapped the change in expenditures and prices into the IMPLAN-derived state energy and economic model to estimate macroeconomic impacts as compared to the baseline "business as usual" scenario. For a more complete description of how the model was created, see the short working paper, "Modeling State Energy Policy Scenarios," available from Environment Colorado Research & Policy Center.[101]

KEY ASSUMPTIONS

Key assumptions used in the economic modeling are as follows:

Generation Costs

Generation costs for renewable energy and for the coal fired power plants that fill in the gap between renewable energy and total additional energy demand are outlined in Table 7.

Local Impacts

To take into account the fact that all economic activity is not necessarily tied to Colorado, we assume that 70 percent of all expenses for renewable technology, including manufacturing, installation, financing and ongoing operation and maintenance, will be local. We also assume that 70 percent of investment will happen in Colorado and 70 percent of any energy bill savings will be respent in the Colorado economy.

Local Program Spending	0.7
Local Investment	0.7
Local Respending / Savings Ratio	0.7

Consumer Savings and Price Dynamics

We assumed that renewable energy would have the effect of reducing upward pressure on the price of natural gas and coal, which are set by a regional and national market. Based on estimates of how much natural gas and electricity would be saved compared to the base case forecast, we predicted change in national demand. In turn, the change in national demand was translated into an estimate of the effect on electricity and natural gas prices in Colorado.

Natural gas prices were calculated using the following coefficients:[102]

	Intercept	Year	Quantity	Deflator
Natural Gas	0.0052	-0.1485	2.0817	1.0101

And the following equation:

[Intercept] * (Number of years since 2003)^[Year] * [National Demand]^[Quantity] / [Deflator]

To the extent that other states adopt energy efficiency programs and renewable energy standards and reduce their fuel demand, it will have positive impacts on Colorado's economy. The effect of policies established in other states or at the federal level are not modeled in this report.

Table 7: Generation Costs

Generation Costs (in 2001 dollars)	Renewable Energy Portfolio[103]	New Coal Plants[104]
Investment ($/kW)	$1,150	$1,300
O&M ($/kWh)	$0.015	$0.015
Fuel Cost ($/kWh)	$0.000	$0.017
Capacity Factor	0.34	0.85
Heat Rate (Btu/kWh)	n/a	9200
Learning Rate per year	0.98	0.99
Initial Cost ($/kWh)	$0.072	$0.058
Air Emissions Rate	0%	100%

Appendices

A Note on Electricity Units

Megawatts (MW) are the standard measure of a power plant's generating capacity, or the amount of power it could produce if operating at full capacity. Utilities measure their ability to supply demand on the grid at any one time in terms of MW. One MW equals 1,000 kilowatts (kW). One thousand MW equals one gigawatt (GW).

Power plant output and electricity consumption over a fixed length of time are measured in terms of megawatt-hours (MWh). For example, a 50 MW power plant operating at full capacity for one hour produces 50 MWh of electricity. If that plant operates for a year at full capacity, it generates 438,000 MWh of electricity (50 MW capacity x 8,760 hours/year). To give a sense of scale, an average household uses about 10 MWh of electricity each year.

Most plants do not operate at full capacity all the time; they may be shut down for maintenance or they may be operated at only part of their maximum generating potential because their power is not needed or their power source (such as wind) is not available. The actual amount of power that a plant generates compared to its full potential is reported as its capacity factor. Thus a 50 MW plant with a 33 percent capacity factor would produce 144,540 MWh of electricity in a year (50 MW x 8,760 hours/year x 33% capacity factor).

Key Economic Multipliers for Colorado

Table A1: Type I Multipliers for the Colorado Economy (2001 Dollars)[105]

SECTOR	Type I Multiplier Employment (Per $MM of Final Demand)	Type I Multiplier Compensation (Per Dollar of Final Demand)	Type I Multiplier Value-Added (Per Dollar of Final Demand)	Labor Productivity Growth (Percent/Year)
Agriculture	12.6	0.208	0.615	1.54%
Oil and Gas Extraction	3.6	0.175	0.714	2.66%
Coal mining	5.2	0.303	0.726	2.66%
Other Mining	5.3	0.302	0.773	2.66%
Electric Utilities	3.0	0.210	0.785	2.80%
Natural gas distribution	2.7	0.197	0.495	3.40%
Construction	11.7	0.414	0.735	2.00%
Manufacturing	6.4	0.342	0.562	2.30%
Wholesale trade	8.1	0.444	0.849	1.50%
Transportation and Public Utilities	11.9	0.504	0.762	2.80%
Retail Trade	18.3	0.457	0.829	1.50%
Services	12.0	0.395	0.796	0.40%
Finance	8.9	0.405	0.775	1.50%
Government	10.1	0.549	0.940	0.40%

Definition of Clean Biomass

Some technologies categorized as "biomass" are actually toxic and should be avoided, including waste and tire incineration. Environment Colorado Research & Policy Center defines clean biomass as:

1) Any plant-derived organic matter available on a renewable basis;
2) Non-hazardous plant matter waste material that is segregated from other waste materials and is derived from:
   a) an agricultural crop, crop by-product or residue resource;
   b) waste such as landscape or right-of-way tree trimmings or small diameter forest thinnings, but <u>not including:</u>
      i) municipal solid waste,
      ii) recyclable post-consumer waste paper,
      iii) painted, treated, or pressurized wood,
      iv) wood contaminated with plastic or metals, or
      v) tires;
3) Gasified animal waste;
4) Digester gas;
5) Biogases and biofuels derived, converted or processed from plant or animal waste or other organic materials; or
6) Landfill methane.

Any biomass combustion must meet the best available control technologies for emissions. Preference should be given for gasified biomass technologies.

Notes

[1] All dollar figures are reported as undiscounted 2006 dollars.

[2] Demand growth: Colorado Energy Forum, *Colorado's Electricity Future: A Detailed Look at the State's Electricity Needs and Electricity's Economic Impacts,* September 2006.

[3] Modeled impact of Amendment 37 (See Methodology) compared to demand growth projections described in Note 2.

[4] Steve Raabe, "Coal's Power Surge: The Rising Cost of Natural Gas Generates a Move by Utilities to Build the State's First Coal-Fired Power Plants Since 1982," *Denver Post*, 1 October 2006.

[5] See e.g., Argonne National Lab and Environmental Protection Agency, *Engines of Growth: Energy Challenges, Opportunities, and Uncertainties In the 21st Century*, January 2004, available at www.4cleanair.org/members/committee/ozone/EnginesofGrowth.pdf; Environment California, *Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California*, July 2003; Kammen, D., and Kapadia, K., University of California, Berkeley, *Employment Generation Potential of Renewables to 2010*, 2002; Hewings, G., Yanai, M., Learner, H., et al., Environmental Law and Policy Center, *Job Jolt: The Economic Impacts of Repowering the Midwest*, 2002; Tellus Institute, *Clean Energy: Jobs for America's Future*, October 2001; Union of Concerned Scientists, *Renewing Where We Live: A National Renewable Energy Standard Will Benefit America's Economy*, 2002 and 2003; Skip Laitner and Marshall Goldberg, for Land and Water Fund of the Rockies, National Renewable Energy Laboratory and Arizona State Energy Office, *Arizona Energy Outlook 2010, Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy,* July 1997.

[6] Multipliers derived from: Minnesota IMPLAN Group, *2004 Data for the State of Colorado*, Stillwater, Minnesota, 2006. See Appendices for a full list of multipliers.

[7] "Xcel Meets Amendment 37 Goals Years Early," *Denver Business Journal*, 10 October 2006.

[8] Renewable Energy Policy Project, *The Work That Goes Into Renewable Energy*, November 2001. As the industry matures and takes advantage of economies of scale, this number will decrease.

[9] John Rebchook, "Wind Turbine Facility Planned," *Rocky Mountain News*, 20 January 2007.

[10] Daniel Kammen and Kamal Kapadia, *Employment Generation Potential of Renewables to 2010*, 2002.

[11] Linda Hardesty, "The Ascent of Solar Manufacturing in Denver," *Colorado Green Business*, 9 January 2007.

[12] Pennsylvania Department of Environmental Protection, *DEP Secretary McGinty Receives Alternative Fuels and Renewable Energy Leadership Award; Cited for Accelerating the Commercialization of Alternative Fuels and Renewable Energies* (Press Release), 6 December 2006.

[13] Texas SEED Coalition and Public Citizen, *Renewable Resources: The New Texas Energy Powerhouse,* September 2002.

[14] Craig Cox, Interwest Energy Alliance, *Wind Energy for Rural Economic Development*, Presentation to Nevada Public Utilities Commission RPS Procurement Workshop, Carson City, Nevada, 18 May 2006.

[15] See Note 23.

[16] See Note 24.

[17] S. Tegen, National Renewable Energy Laboratory, *Comparing Statewide Economic Impacts of New Generation from Wind, Coal and Natural Gas in Arizona, Colorado and Michigan*, Technical Report NREL/TP-500-37720, May 2006.

[18] Reports using a variety of methods and conditions all reach the same conclusion. See Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, University of California, Berkeley, *Putting Renewables to Work: How Many*

Jobs Can the Clean Energy Industry Generate? 13 April 2004.

[19] Units on the y-axis are expressed in average megawatts, or the nameplate capacity of a facility times its capacity factor, or the percentage of time the facility can run at full capacity. See Note 28.

[20] See Note 24.

[21] M. Brower, et al., Union of Concerned Scientists, *Powering the Midwest: Renewable Electricity for the Economy and the Environment*, 1993.

[22] Lease payments range between 2% to more than 10% of yearly gross revenues, depending upon competing land uses (National Wind Coordinating Committee, *The Effect of Wind Energy Development on State and Local Economies*, Wind Energy Series #5, January 1997, available at www.nationalwind.org); an assumed lease payment of 2.5% is common (see National Wind Coordinating Committee, *The Effect of Wind Energy Development on State and Local Economies*, Wind Energy Series #5, January 1997; AWEA, Texas SEED Coalition and Public Citizen, *Renewable Resources: The New Texas Energy Powerhouse*, September 2002).

[23] Calculated assuming a wind energy deployment schedule as described in the methodology section, lease term of 2.5 percent of gross revenue, and a contract price of 3.5 cents per kWh. Dollar figure not discounted.

[24] See Note 24.

[25] Ibid.

[26] For the purposes of this calculation, we ignore any potentially relevant tax limitation provisions of the Colorado Constitution and statutes. Tax income is reported in non-discounted 2006 dollars, representing total payments from 2007 through 2020. The value reported here follows from the renewable energy development scenario described in the methodology section and the following assumptions: We assume that each facility depreciates on a linear schedule over a 25 year useful life, that 29 percent of market value is the state assessed value, and that the average property tax rate is 7 percent of the assessed value per year. See S. Tegen, National Renewable Energy Laboratory, *Comparing Statewide Economic Impacts of New Generation from Wind, Coal and Natural Gas in Arizona, Colorado and Michigan*, Technical Report NREL/TP-500-37720, May 2006.

[27] See Note 27.

[28] Ibid, p. 9.

[29] Ibid, p. 9.

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