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Comparing Statewide Economic Impacts of New Generation from Wind, Coal, and Natural Gas in Arizona, Colorado, and Michigan

S. Tegen

Technical Report
NREL/TP-500-37720
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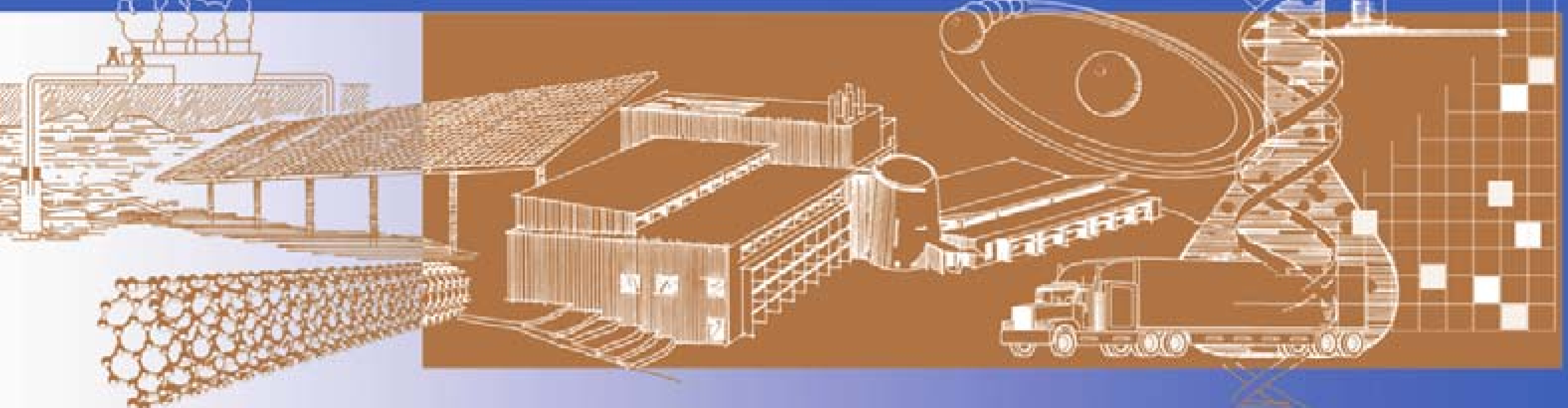

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Abstract

With increasing concerns about energy independence, job outsourcing, and risks of global climate change, it is important for policy makers to understand all impacts from their decisions about energy resources. This paper assesses one aspect of the impacts: direct economic effects. The paper compares impacts to states from equivalent new electrical generation from wind, natural gas, and coal. Economic impacts include materials and labor for construction, operations, maintenance, fuel extraction, and fuel transport, as well as project financing, property tax, and landowner revenues. We examine spending on plant construction during construction years, in addition to all other operational expenditures over a 20-year span. Initial results indicate that adding new wind power can be more economically effective than adding new gas or coal power and that a higher percentage of dollars spent on coal and gas will leave the state. For this report, we interviewed industry representatives and energy experts, in addition to consulting government documents, models, and existing literature. The methodology for this research can be adapted to other contexts for determining economic effects of new power generation in other states and regions.

Summary

This paper compares direct spending in Arizona, Colorado, and Michigan on the new construction and operation of three types of power plants: wind power, a natural gas combined-cycle baseload plant, and a coal-fired power plant. We follow the flow of money for each new plant and measure which dollars would be spent in Colorado (for example, dollars paid to a Colorado company to purchase concrete for a plant foundation or dollars spent on Colorado concrete workers' salaries). To reach a fair comparison, spending is calculated based on the same amount of energy generated by each plant—approximately 2,000,000 megawatt-hours (MWh) per year.[1] This amount of electricity would be generated by a 270-megawatt (MW) natural gas plant with an 87% capacity factor. Rated capacities of the coal and wind plants were adjusted so that they would generate the energy equivalent to the gas plant. The coal plant would be 280 MW in Arizona and Colorado but 300 MW in Michigan (VanderVeen 2005).[2] The wind plant capacity will vary in each state according to the wind regime. The components of each power plant included in this analysis are parts and labor for construction, operations and maintenance (O&M), fuel extraction, and fuel transport, in addition to money spent on financing, landowner royalties, and property taxes.

Research components:

- Construction
- Operations and maintenance
- Fuel extraction
- Fuel transport
- Land leases
- Financing
- Property taxes

[1] In this study, coal, gas, and wind comparisons are based on an equivalent amount of energy produced. Each resource will produce the equivalent energy from a 270-MW natural gas plant with a capacity factor of 87%. To equal the output of the gas plant, this means that a coal plant with an 80%-85% capacity factor will need 280 MW of generating capacity, and wind farms with a capacity factor of 25%-35% will need 680 MW-900 MW. Capacity factors for wind were determined by aggregate data from developers in each state.

[2] According to the assumption in the VanderVeen report for the Michigan Public Service Commission that a coal plant will have the capacity factor of 80% versus 85% in Colorado and Arizona.

Of the various impacts to the state economy involved in power generation over 20 years, each state has varied results that show equivalent generation of wind power will bring the highest direct economic benefit to the state. Tax revenue (especially for wind plants) plays a significant role in the benefits to the state's economies because a larger tax base makes it possible to provide more funding for public goods, such as parks, roads, and schools. If power plant owners negotiate a deal with localities in which they build so that they are exempt from property and sales taxes, the local economy may benefit from some job creation or fuel sales, but it will not receive what can be very significant property tax benefits over the life of the plant. As shown in the results, much of the labor force for plant construction, as well as for operations, is often brought in from outside each state. When the labor forces for construction or fuel transport come from within the state's borders, economic impacts can be considerable, regardless of where the fuel is initially extracted. Of course, if coal or gas comes from the same state where the power plant is located, the economy is more likely to benefit from the sale of the fuel.

Results are based on the best available data from industry and government sources. Examples of uncertainties in the data are represented for each generation technology in the Results section of this paper. The methodology detailed in this report is useful for researchers in regions where there are questions about which energy source to build next and which generation source most benefits the local economy. Results may also help inform decision-makers who want to maximize benefits to their state by providing an energy-equivalent method of comparison.

Introduction and Background

In the United States, the need for additional electricity generation continues to increase due to the growing population and demand from energy consumers. The Department of Energy predicts that this growth will continue (Figure 1).

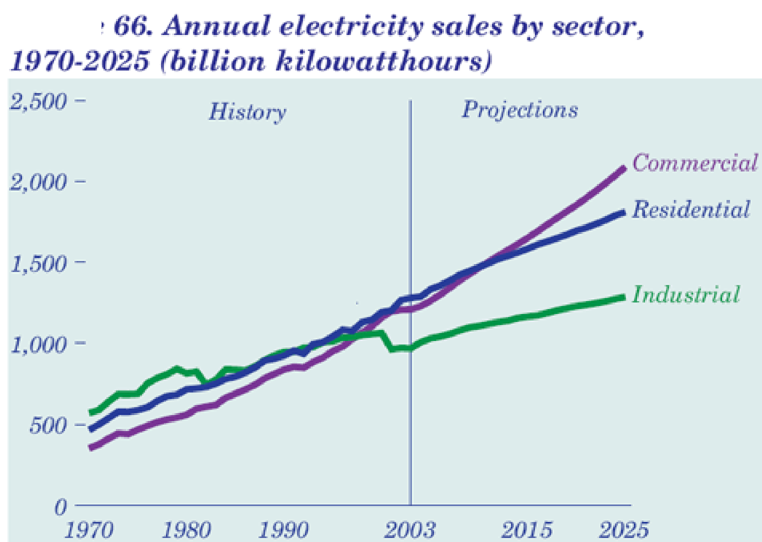

Figure 1. Prediction of annual electricity sales from 1970 – 2025 by the Department of Energy's Energy Information Administration (released February 2005)

With a growing focus on domestic power resources for energy independence and the need for new employment opportunities, it is important for decision-makers to understand the economic impacts of energy generation sources on their local economy. For example, when a new power plant is built, laborers will be needed to pour the concrete for the foundation of the plant. If the workers come from within the state, this new project will contribute to the state's economic well-being by paying state residents.

This paper compares the flow of money into and out of states from three potential sources of new electricity production. We examine the impact of developing three new hypothetical power plants to produce electricity from coal, natural gas, and wind. We also explore how much money each new plant would contribute to Colorado's economy by adding labor from Colorado, equipment sold in Colorado, landowner payments, and property taxes. As indicated in Table 1, coal, gas, and wind comparisons will be based on the amount of energy produced.[3]

Table 1. Energy Equivalents

	Capacity Factor	Equivalent MW Needed	MWh Produced per Year
Coal	80%-85%	280 - 300	~ 2,084,880
Gas	87%[4]	270	~ 2,057,724
Wind	25%-35%	680 - 900 (1.5-MW turbines)	~ 2,084,880

The equivalent megawatts are determined by multiplying the capacity by the capacity factor by the number of hours in a year. For example:

270MW x 0.87 x 8760 hrs/year = 2,057,724 MWh.

The results of this study may be used in policy analysis for issues such as potential renewable portfolio standards and system benefits charges or in decisions based on maximization of economic benefits to states from their natural resource potential. Results also indicate how much the specific components of new energy generation will benefit the states' economies.

Existing Research

Many informative studies about the impacts of electricity production have been performed, including an examination of which energy sources create the most jobs or produce the greatest advantages for consumers or the environment (Madsen et al. 2002; National Wind Coordinating Committee 1997; Clemmer 2001; Goldberg et al. 2004; Kaas Pollock and Gagliano, 2004; Regional Economics Applications Laboratory 2001; Wind Energy Creates 1995). The body of literature about wind's economic development impacts and the uncertainty of gas pricing is growing (Wiser and Kahn 1996), as well as

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[3] Energy from each source is an estimate of potential generation for comparison purposes and is independent of operational constraints, including those that might be driven by changes in fuel prices.

[4] 87% is the highest capacity factor given to a natural gas power plant by the Energy Information Administration. This is used as a basis for comparison. Currently, natural gas prices are too high to make construction of a baseload natural gas plant economically feasible, but prices of gas and other resources will vary in the future. This study does not consider costs to consumers, but it should be noted that at present fuel prices, an 87% capacity factor is unlikely.

several modeling tools to calculate economic impacts (Goldberg et al., 2004; Costanti 2004). The methodology for this report was initially developed for a paper describing the economic benefits to Colorado published in the Global WINDPOWER 2004 conference proceedings (Tegen 2004). But a comparison of multiple states' resources and their direct economic impacts from sources of new utility-scale generation has not been conducted. Unlike other work, this study compares direct impacts specific to statewide economies. Wherever possible, data were gathered from state-specific energy companies[5] and energy experts, instead of using national averages and extrapolating costs for each component.

Goal and Scope

The scope of this project is the measure of direct economic impacts from new sources of electricity. In other words, we calculated how much money will be spent in each state for salaries, purchasing materials, land revenues, financing, and taxes when new power plants are built and operated. For each resource, the study compares the following components of new electricity generation:

- Materials and labor for construction
- Materials and labor for O&M
- Materials and labor for fuel extraction (gas well or coal mining)
- Materials and labor for fuel transport (including railroads, shipping, and gas pipelines)
- Project financing
- Landowner revenues
- Property taxes

When analyzing direct economic impacts of coal, we include parts and labor for coal mining and coal transport (from the mine to the power plant by railroad or ship) under the fuel component for each state analyzed. For natural gas, we include parts and labor for gas extraction at the wellhead and parts and labor for gas pipeline costs. This research does not include indirect or induced effects of energy production (e.g., plant construction worker's hotel bills).[6] The new power generation facilities are assumed to be grid connected. Other assumptions are found in the Assumptions section.

The primary goal of this research is to provide a careful state-specific comparison of the money flow from new power generation. Project results are not meant to represent national averages or economic impacts in other locations. However, strategies and models for data gathering used in this study will be helpful for others working on similar projects (see Lessons Learned). It is important to remember that data for this paper were gathered in early 2005 and that the results presented here reflect these inputs. The

[5] Companies include developers, utilities, municipalities, private wind generators, pipeline companies, coal railroad companies, and energy-equipment companies.

[6] Indirect effects are additional economic activities stimulated by direct spending associated with power plant construction and operations (e.g., hotel revenue from out-of-state workers). Induced impacts are increases in economic activity associated with increased disposable income created by power plant constructions, operations, and other power plant spending (e.g., increased spending on clothing due to increase in family incomes from power plant work salaries).

purpose of this paper is to introduce a useful methodology. When utilizing this methodology in the future, inputs should be changed to reflect the most current data available.

Methodology

The methodology for this project includes a number of data-gathering techniques. In addition to the aforementioned interviews with analysts, government energy offices, and industry contacts, we also conducted literature searches. We used the BaseCase database from Platts, a division of the McGraw-Hill Companies, Inc., and the jobs and economic development impacts (JEDI) economic development analysis tool for wind projects from the National Renewable Energy Laboratory (NREL).[7] After sufficient economic data were gathered for the chosen energy sources, we sent the assumptions to energy experts for each resource and compiled in a spreadsheet format most useful for comparisons of each power source.

For each component of the study (e.g., labor for natural gas extraction), we compared the best-estimate value based on $/kilowatt-hour (kWh).[8] Next, sensitivity analyses were performed to determine how much higher and how much lower the dollar value could potentially be. For example, if some industry reports conclude that average annual O&M costs for natural gas are $15.50/kilowatt (kW, nameplate capacity), but reliable models report that the same costs are $27/kW, it is necessary to conduct further analysis and determine high and low ranges around a best-estimate dollar amount. Each component of this study is represented by a best-estimate cost with a range of uncertainty above and below it, when applicable. It is necessary to explain each dollar category or "component" so that the scope, assumptions, and uncertainties are clear when viewing the project results.

Components of the Estimated Direct Economic Impacts

Construction

For each energy resource, we conducted many interviews to determine prices of new construction. We assumed that construction would begin in 2005. Interviews were primarily with industry contacts or from each state's energy experts. In Michigan, we relied on experts and the Michigan Public Service Commission's current reports. The construction component includes the capital cost of equipment as well as overhead, legal and permitting costs, and engineering. It also includes the cost of land, except for annual land-lease payments (e.g., to farmers paid for wind turbines on their land). The construction phase of a new power plant will vary for each generation technology. Constructing a coal plant of this size can take 3 to 6 years, whereas natural gas plants typically take 1.5 to 2 years, and wind plants can take between 6 months and 1 year to develop. Wind generation of such large size would likely take about 1 year.

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[7] An easy-to-use tool to analyze potential jobs, economic development, and impacts from wind development. www.windpoweringamerica.gov/filter_detail.asp?itemid=707

[8] Some costs are typically reported in $/kW or $/megawatt, but we used a $/kWh calculation for a fair comparison.

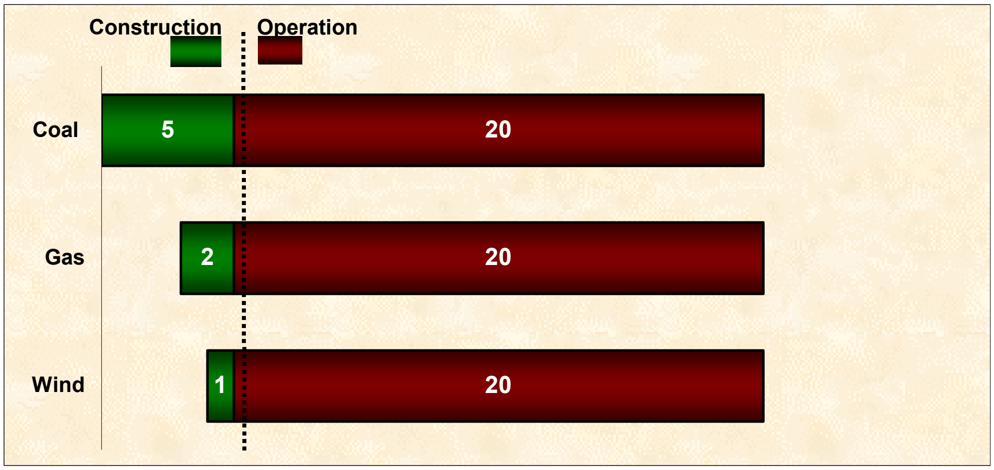

Figure 2. Construction lead time for coal, gas, and wind plants

Financing

It is unlikely that an in-state bank would finance a utility-scale power plant project. Local banks are increasingly willing to finance new wind projects, but those projects are usually much smaller than 280-MW projects (typically 50 MW or less). A variety of financing techniques exist for power plants, but this study assumes financing by a utility or large bank. Options for funding a wind project are expanding, and there are examples of community-financed projects in which community members own the project or team with larger corporations to fund a wind project. In the latter case, known as the "flip" model, a corporation owns the wind project for the first 10 years while realizing tax incentives and then "flips" ownership to the local community. There are many options for funding wind generation. For this study, whether the project is financed in state and by what amount are important elements. We assumed that none of the financing for new power generation would be from within the states, based on interviews with Colorado lenders. Researchers may choose to use this methodology with the flip model or other community financing options and learn how in-state benefits are increased.

Operations and Maintenance

O&M spending from a new power plant includes unscheduled but routine maintenance, preventive maintenance, and costs of scheduled major overhauls. Some O&M estimates also include property tax and landowner payments, but this study separately examines those and does not incorporate them under this heading. O&M spending was difficult to determine for natural gas, whereas the energy community agreed on coal and wind O&M spending. Dollars spent for natural gas O&M ranged from $7.6/kW to $20/kW. We used $10-$14, depending on state data, for our average because it is from actual recent power plant figures (BaseCase). We used actual data from new power plants whenever possible and spoke with representatives from each energy generation source to determine the breakdown between parts and labor. In most cases, industry employees agreed that labor (not materials) is the much larger component of O&M costs (between 70% and 99%). One developer said labor might only comprise 60%, but most agreed it was a higher percentage. Variations are reflected in sensitivity analyses.

Fuel Extraction and Transport

This study includes the extraction of gas and coal from the well or mine and the transport by pipeline or railroad to the utility's power plant. We spoke with representatives from the railroads and pipeline industries to obtain breakdowns of fuel costs (extraction vs. transport and labor vs. parts). Breakdowns for coal vary greatly. For example, if the coal is from Colorado, most of the direct dollar outflow for transport will also be by Colorado laborers, and this makes a significant difference in the results. In Michigan, none of the coal is from Michigan coal mines, but a large coal transport industry (rail and ship) is based in Michigan; thus some of the direct expenditures for transporting the imported coal will benefit Michigan's economy.

Using this scope of work, wind power has no economic benefits in the category of fuel extraction because the wind is free. Of course, having zero fuel costs could be viewed as a cost advantage for utilities and their customers, but this study considers the state economy's overall impact from new power generation, not utility or customer costs or prices.

Landowner Revenue

In this study, landowner revenues for power generation apply only to wind power development. Studies show that the most common way for utilities to add wind to their resource portfolios is to purchase generation from private companies instead of owning and operating wind farms (Wiser and Kahn 1996, p.1). This means that the electric output from a privately owned wind farm, such as the wind farm in Lamar, Colorado, is sold to investor-owned utilities (IOUs) under long-term contracts. The company that owns the wind farm usually leases land for its turbines from rural landowners, who are typically farmers or ranchers. Wind developments are sited in rural areas for various reasons, including wind speeds and site selection processes. Annual payments range from $1,500 to $6,000 per wind turbine per year, depending on individual contracts and size of turbines.[9] Land leases can be structured in several ways. The most common in the wind industry is to base lease payments on a percentage of gross revenue from wind power production. Normally, a guaranteed minimum annual payment is included in a lease to cover periods in which the project may be inoperable (National Wind Coordinating Committee). Some landowners choose to accept payments per turbine instead of payments based on gross revenue so that they are assured a set income.

It is possible for a utility to own the entire wind project and make payments to farmers directly or even to buy the land outright. In another situation, an outside company, either a utility or non-utility, could purchase land for wind turbines up front and therefore not be required to make land payments to landowners after the initial payment. These cases are unlikely but possible.

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[9] Net landowner revenues: landowners must calculate their cost of lost productivity and subtract it from their income per turbine. Ranchers are usually not affected because animals can graze among installed turbines. A Pacific Northwest study shows that farmers gain approximately 85% of their gross revenue when land loss is figured in.

For coal and gas plants, power plant owners usually purchase their land and include this under their construction costs. Much less land is needed for a coal or gas plant than for a wind farm, considering different technologies and the 25% to 35% assumed capacity factor for wind compared to much higher capacity factors for fossil-fuel generation.[10] The larger amount of land required for wind projects benefits rural landowners in the form of landowner payments. Although wind plants need access to large land areas, they only use a small fraction for roads, turbine foundations, and electric equipment. More than 90% of the land used for a wind farm can still be used for crops or grazing.

Property Taxes

As mentioned, wind power requires much more land than either a natural gas or a coal plant. More than 400 1.5-MW turbines are required to produce the energy equivalent to a 270-MW natural gas plant with a capacity factor of 87%. Utilities and plant owners may be exempt from property taxes depending on contract negotiations or state incentives. However, if taxes were collected, tax revenue would be greater from a wind plant than from a fossil fuel plant due to the increased size of the project.[11]

In Colorado, property taxes are paid to counties, and all county property taxes are assessed by the State Office of Taxation (the State). The State bases assessments on the value of the utility's or plant owner's "business valuation," or the sum of real property, personal property, tangible assets, and intangible assets.[12] The State then takes 29% of the business valuation to be the assessed value of the company. The assessed value is communicated to each company and county, and property taxes owed to the county are based on power plant location. For example, if Xcel Energy Corporation were to build a coal plant in Pueblo County, Colorado, they would negotiate tax rates with Pueblo County assessors. Counties determine the amount of property taxes based on mill levies, which are specific to each county but are usually higher in rural areas.[13] Annual county mill levies range from 3% (La Plata County) to 9.9% (Phillips County).[14] For this research, we assume 7% in Colorado. Because of the popularity of granting coal and gas plants exemptions from property tax in Colorado, this study assumes that the coal and gas plants will pay property taxes all 20 years, but during the first 10 years, they will only be subject to half of the property tax.

Tax exemption is often automatic for municipally owned utility plants. Tax exemption can play an important role in new power plant development for investor-owned or

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[10] Much less land is needed for the actual power generation. However, land impacts are greater when the entire life cycle of the resource is considered. For example, coal mining sites, including roads and disposal sites, were not included in the scope of this research.

[11] In some states, wind energy projects are exempt from property taxes resulting from increased property value because of wind plant development (NWCC Wind Energy Series).

[12] It is common for utilities to operate in more than one state. In such cases, the Colorado Office of Taxation assesses companies based on total historic cost (depreciation rate plus net book value of assets) per county. According to Deb Meyer, State Division of Property Taxation, intangible assets could be for items like franchising or the worth of a brand name.

[13] Mill levies are a specified rate: 1 mill equals 1/10 of a cent ($0.001) per $1 of property value used to determine the tax or assessment on property. Mill levy taxes are used for things like school districts and road improvements.

[14] Colorado tax information is based on conversations with Mark Walker of the State Office of Taxation.

privately owned utilities. Non-municipally-owned power plants may be exempt from property taxes unless they have non-operating properties, such as land that they do not use. Tax exemption is a great advantage to power plant owners. The utility will often negotiate a deal for tax exemption or partial tax exemption with counties in which they locate a power plant.

For example, in Colorado, agreements between Xcel Energy and the City and County of Pueblo state that, if Xcel builds a power plant there, the company would be forgiven 50% of the total in property taxes over the next 10 years. The City also agreed to forgive sales-and-use tax on the construction of the plant in return for a one-time $13 million payment, which may be used to construct a new building for Pueblo police (Amos 2004). Cities and counties negotiate deals like this because new plant construction and operations bring new jobs to the area. However, as results show, much of the construction and operations labor is brought in from out-of-state. For example, in-state coal plant construction labor accounts for less than 20% of total labor.

In Michigan, the assessed value, or "State Equalized Value," is equal to one-half of the total value for real and personal property. The state's average tax level applied to the assessed value is 5% for annual property taxes. Air and water pollution control equipment on power plants is exempt from property taxes.

Wind plants in Michigan will not be required to pay property taxes until the year 2013. According to the Michigan Economic Development Corporation, "Alternative-Energy Personal Property" … is exempt from the collection of personal property taxes. This exemption includes (1) "Alternative-Energy Systems," (2) "Alternative-Energy Vehicles," (3) the personal property of an "Alternative-Energy Technology Business," and (4) the personal property of a business not engaged in alternative-energy technology that is used solely for the purpose of researching, developing, or manufacturing "Alternative Energy Technology." However, it is common for a community to negotiate "host fees" in lieu of property taxes from $3,000 - $5,000 per turbine per year. After discussions with a Michigan wind developer about recent projects, we have assumed a $5,000/turbine/year payment for this study.

In Arizona, the assessed value of a plant is 25% of 80% of the installed project cost. Then mill levies are applied to this number to determine county property taxes. The average, and the assumed number for this report, is 7.6%.

Because of specifics of individual project negotiations, taxes for the average new power plant are difficult to predict accurately. As stated, it is fair to assume that a utility-owned plant will likely be partially tax exempt in Colorado, but a privately owned power plant will be required to pay county property tax (Wiser and Kahn 1996). In Michigan, we safely assume that wind projects will not pay property taxes until 2013. For this project, we took examples of current power plant tax estimates and average tax payments from existing plants and applied them to the appropriate size of the new plant. For wind, we used existing plant data in Colorado and estimates in Arizona, and we based Michigan assumptions from the Michigan Public Service Capacity Needs Forum.

Taxes paid on gas wells and for coal mines will not likely increase when 280 to 300 MW of generation are added to the state's system mix. New gas wells and coal mines are not required for this amount of electricity production, so taxes on these items were not included in this study. If all the coal or gas came from within the state and resulting extraction efforts were larger, or if the plant were of larger capacity, it is conceivable that the associated increases in well or mine taxes should be considered.

Sales Tax

We did not separate sales tax in this report. We assume that sales tax is included in the dollar amount of parts, such as the wind turbine shaft, or of processes, such as the natural gas plant construction. To calculate sales tax, a researcher would have to obtain information about which parts of the power plants, fuel extraction, and fuel transport come from within the state or come from a company with an office within the state so that the company may charge sales tax. For example, if wind turbine blades were manufactured in South America or Denmark, but the manufacturing company had an office in Arizona, the wind farm owner would be required to pay Arizona state sales taxes for the wind turbine blade. If the Danish company had an office in Wyoming instead of Arizona, no sales tax would be paid to Arizona. Most companies do not make any of this sales tax information available. However, future studies may include estimated sales tax based on state-specific models. For example, Colorado sales tax is 2.9%, and this could be added (or broken out from existing dollar amounts) to parts purchased in Colorado, depending on whether the sales tax is assumed to be included.

Discount Rate

For purposes of this research, results are displayed without a discount rate applied. However, discount rates of 5% and 7% were applied to some results, and direct spending can easily be calculated with a discount rate of the researcher's choice. In the Results section of this report, we show direct impacts without the discount rate, except when specifically noted. This is due to the wide range of discount rates used by government, policy makers, and industry.

State Specifics

The Components section of this report above has detailed each area of dollar flow, including some state specific information (see Property Taxes). The Assumptions section explains general suppositions for the paper. Some areas of inquiry require individual explanation for each state's energy background and attributes, which are in this section.

Arizona

In Arizona, most of the state's power comes from imported coal. (Coconino County, Arizona, has some coal mines, but they supply an electricity generation facility in Nevada). Coal for a new coal plant would likely come from Wyoming or New Mexico (Tri-State Generation and Transmission Association, Inc.). The new plant is assumed to be a sub-critical plant, based on the most recent Arizona coal plant proposals (Springerville). The coal plant's capacity factor is assumed to be 85%.

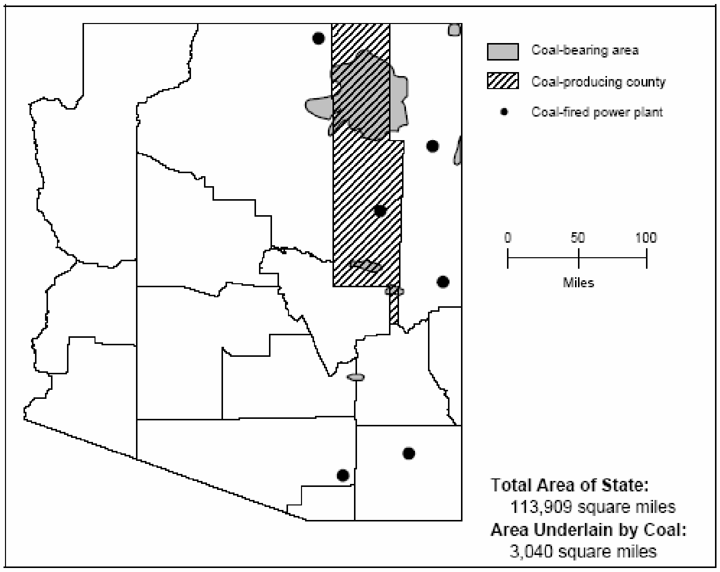

Figure 3. Arizona's coal-producing area. Source: EIA, 1999

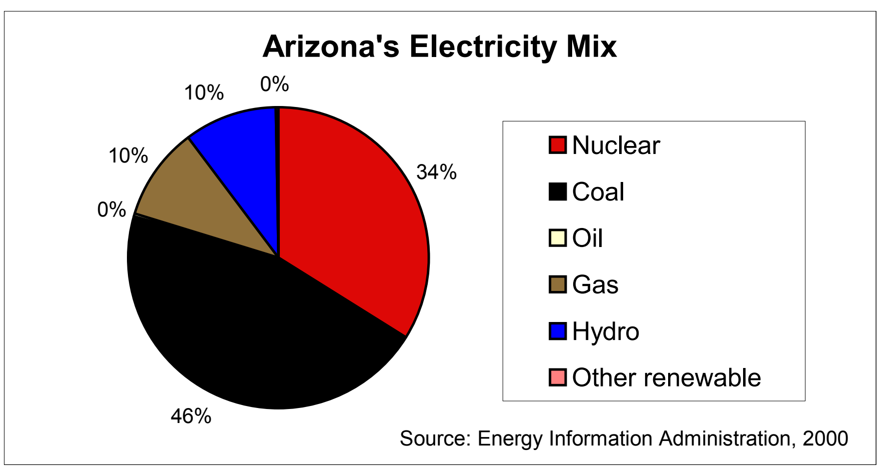

Figure 4. Arizona's electricity mix. Source: EIA, 2000

Arizona also imports its natural gas (see the Assumptions section for further aspects and complications on natural gas). The capacity factor for wind in Arizona is assumed to be 30% for this research, so the wind plant would require 520 1.5-MW turbines to equal 780 MW and generate the necessary amount of electricity.

Colorado

In Colorado, the coal plant is assumed to be a super-critical plant based on the most recent proposed coal plant in Colorado (Xcel Energy's Comanche III coal plant in Pueblo). Coal will most likely be transported by rail from the Powder River Basin in Wyoming. The coal plant's capacity factor is assumed to be 85%.

Colorado has natural gas fields, and this study assumes that 40% of the natural gas for the new plant comes from within the state's boarders. Colorado has a considerable wind resource, as shown by the pink and purple areas (Figure 5).

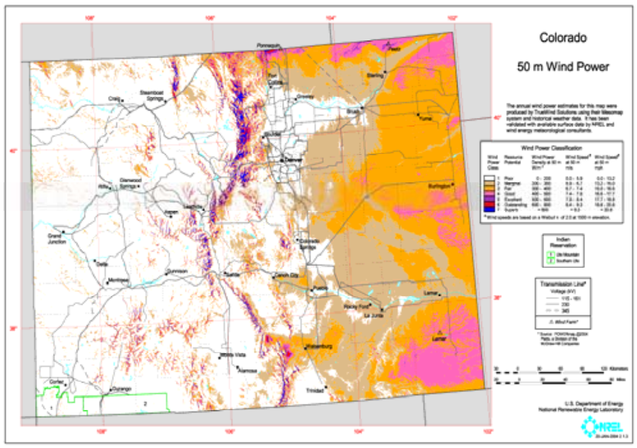

Figure 5. Colorado's wind resource at 50 meters. Source: NREL, 2004

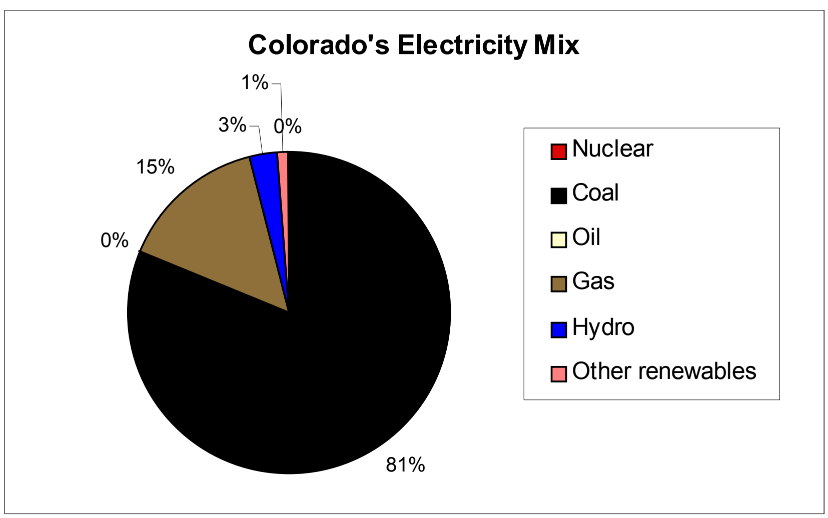

Figure 6. Colorado's electricity mix. Source: EIA, 2000

Michigan

Like Colorado, Michigan's power mix relies heavily on coal, with a small amount of natural gas and almost no wind power. Michigan also imports coal to feed its power plants. Michigan does have some natural gas extraction fields, so we assume that 25% of natural gas used in Michigan comes from Michigan. The multiple in-state pipeline, railroad, and shipping companies provide direct benefits to the economy. For example, if the coal is transported from Wyoming, some of the labor and materials for the railroad cars are from outside Michigan. For the base cases in this study, we assume that 50% of the natural gas transport labor is based in-state and 60% of the coal transport labor is based in Michigan. These current estimates are from a report for the Michigan Public Service Company (VanderVeen 2005).

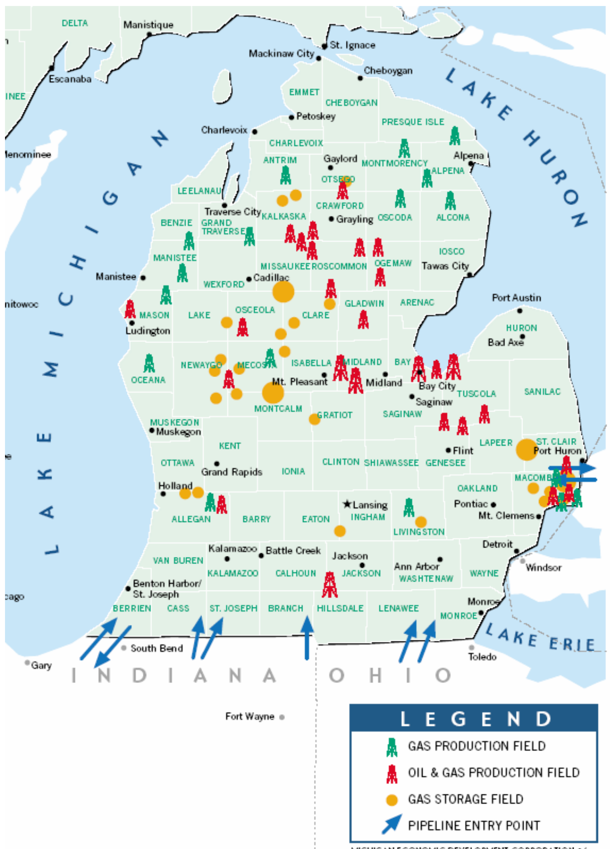

Figure 7. Michigan's gas and oil production fields. Source: Michigan Economic Development Corporation, 2000

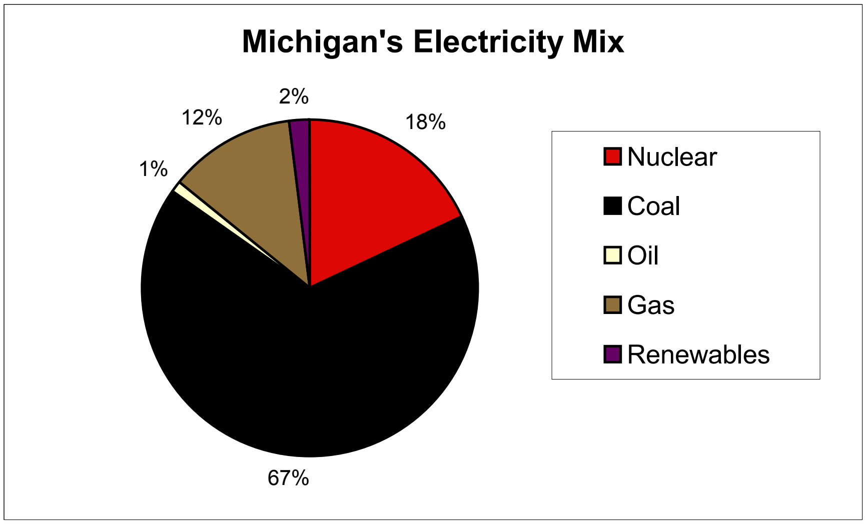

Figure 8. Michigan's electricity mix. Source: EIA, 2000

Assumptions

Assumptions for this study are based on scenarios that are most probable for building new energy-generation capacity. It is assumed that energy efficiency and demand-side management options have been considered earlier in the decision-making process. In this case, new energy generation is utility-scale and grid connected.

The new wind, coal, or gas power plant would produce approximately 2,000,000 MWh per year for 20 years, and construction would begin in 2005. Power would be generated in each state for its ratepayers. We used the most recently proposed coal, gas, and wind projects in each state to determine our assumptions.

The natural gas plant is assumed to be a baseload combined-cycle plant. It is very difficult to determine the exact wellhead in a power plant from which natural gas stems from (Figure 9). Natural gas flows through pipelines and is mixed with gas from many sources before it arrives at the plant. Interviews with 15 energy analysts and natural gas industry employees in and around Colorado provided answers that ranged from "most of our gas is from Wyoming" (Mercatur Energy) to "80% of the gas should be from Colorado if the plant is far enough from Colorado's borders" (Colorado Oil and Gas Commission). For this study, we assume that none of the gas used in the new power plant would be from Arizona, 40% of gas is extracted from Colorado's natural gas wells, and 25% of Michigan's gas will be from Michigan.

We also assume that the new gas plant would have a capacity factor of 87%. This is consistent with new efficient gas plants that are currently under construction.[15] However, at the present (May 2005) high fuel price, some companies choose to only run their gas peaking plants – not baseload (these plants are too expensive to utilize for electricity

[15] Energy Information Administration's maximum capacity credit assumption. Xcel Energy's combined-cycle gas plant in Fort Lupton, Colorado, was rated 86.5% in 2002.

because of the high gas prices). A report for the Michigan Public Service Commission assumes that natural gas has a capacity factor of merely 35% due to the heightened fuel prices (VanderVeen 2005). In this study, we assume that the price of natural gas will continue to fluctuate but will also be used as a baseload plant when costs for other generation (e.g., pulverized coal) and construction (steel, etc.) also increase in the future. One example of the market fluctuation is EIA data, which show that coal prices are also rising in each region of the country. These rising prices are for spot markets, not long-term fixed contracts, but they show the upward trend in prices nonetheless. The methodology for this report can be used with the assumption that resources have a much lower capacity factor, if required.

We assume that the gas project financing would come from the utility's regular financial lending institution (usually a large national or international bank not located within the state).

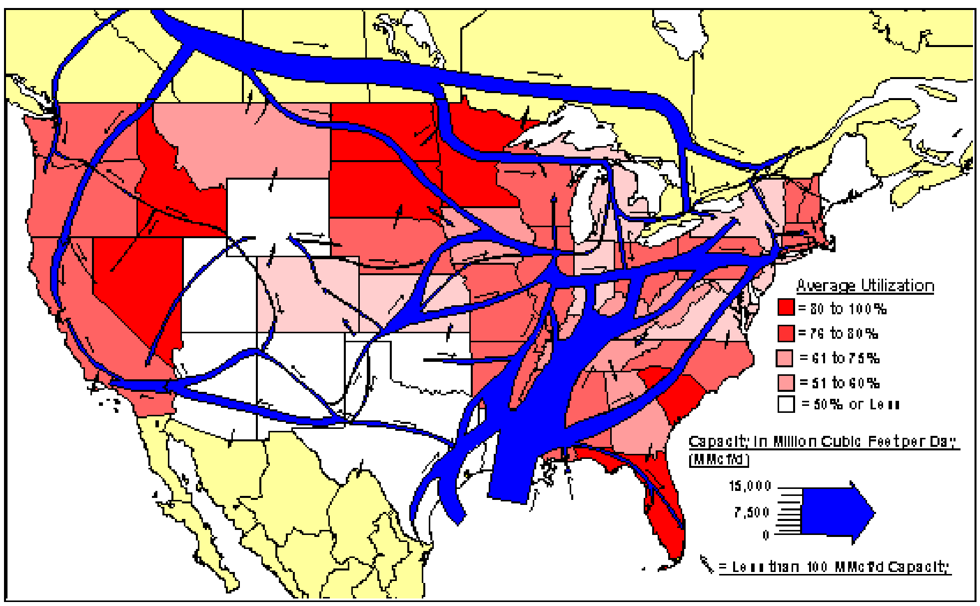

Figure 9. Natural gas transmission line capacities. Source: EIA, 2000

Making assumptions about natural gas prices today and for the next 20 years is risky and will inevitably be somewhat inaccurate. (See Figure 11 for obvious price shifts.) However, we use the EIA's assumptions and include high and low scenarios above and below those predictions. Since the Colorado report (2003 data) (Tegen 2004), prices for natural gas have continued to rise. The assumptions for natural gas base case prices in this study range from \$35/MWh to \$55/MWh, or \$5.2/MMBtu to \$7.9/MMBtu, to incorporate a range of prices. Assumed prices are based on data from actual natural gas plants in each state. Utilities running natural gas plants have long-term contracts for baseload natural gas, so they are not as vulnerable to spot market fluctuations.

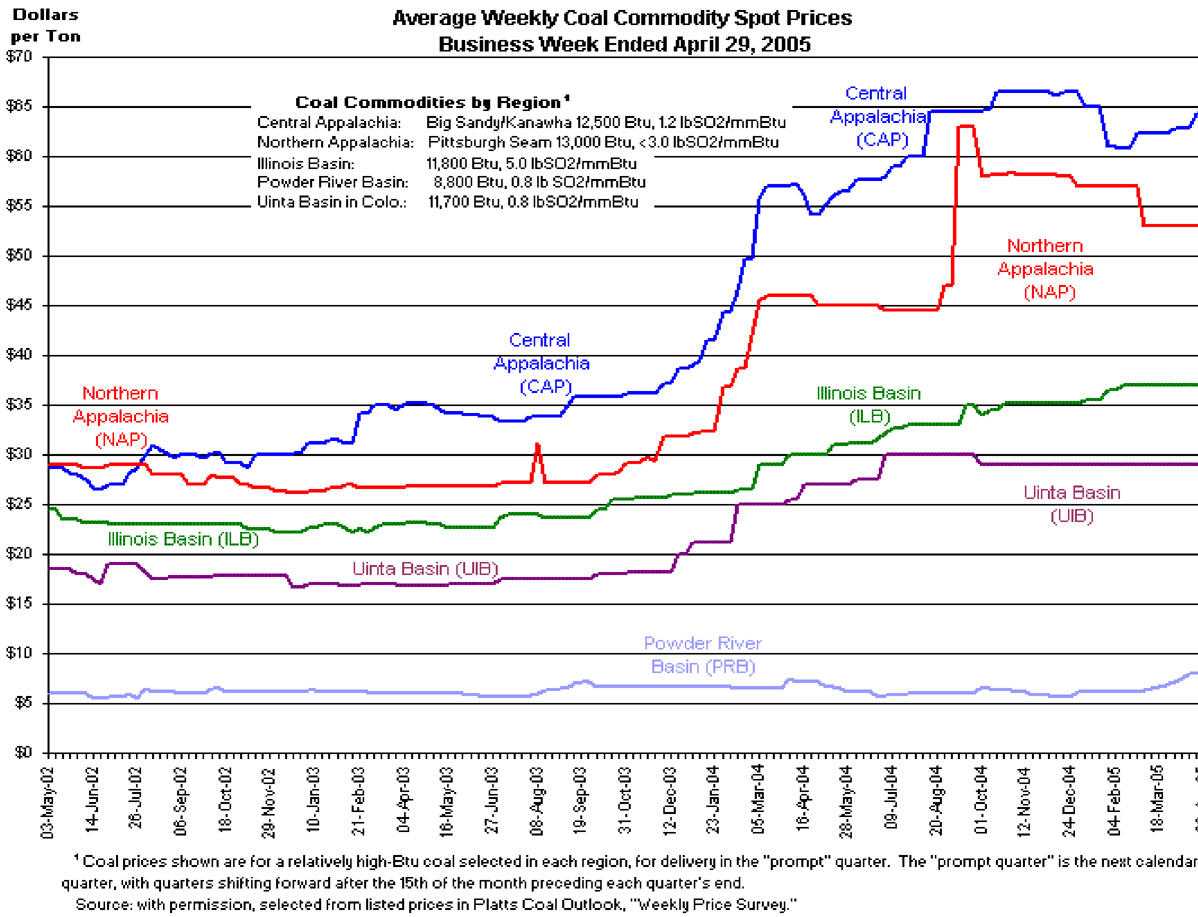

Figure 10. Average weekly coal spot prices ($/ ton) from May 2002 through April 2005. Source: EIA

We assume that the capacity factor for wind power will be 30% in Arizona, 35% for the wind farm installed in Colorado (Milligan, personal communication), and 25% in Michigan (VanderVeen 2005). We also assume that the landowner revenue paid to a landowner is a direct benefit to the state's economy. This study does not try to determine the next step for dollars brought into the economies by using a multiplier or other calculations.

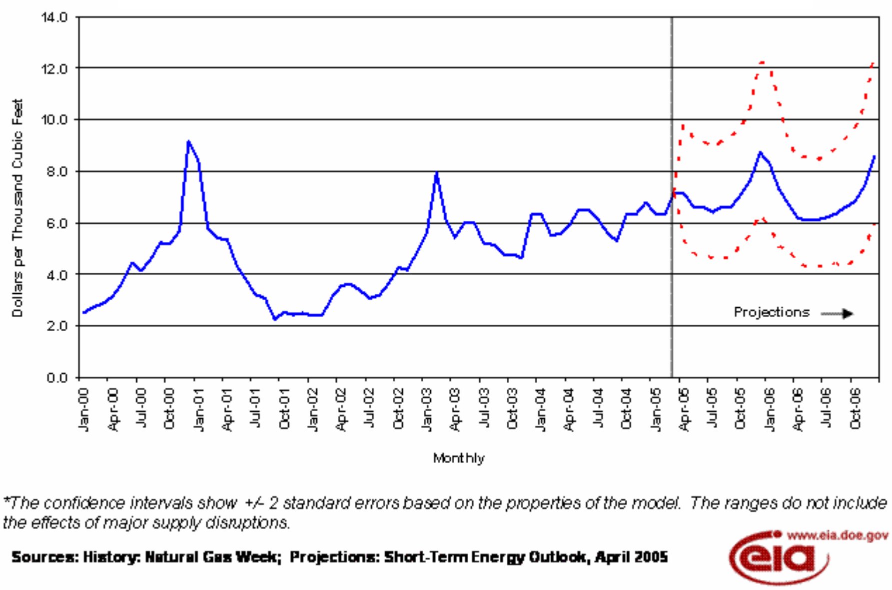

Figure 11. U.S. natural gas spot prices from 2000 to 2006 in $/ thousand cubic feet. Source: EIA

Results

The results show that benefits to the three state economies from energy resources vary greatly, depending on specifics of each power plant project and its contracts. For fossil-fuel-fired power, dollars spent on fuel are a significant benefit *if* the fuel is produced in state or transported by in-state industry and workers, or both. As expected, results show that states are positively impacted by new power generation when local labor is used to install equipment and operate the new energy-generating facility.

Results in all three states show that adding wind facilities will provide a greater economic benefit to the state economy, due in large part to payments for property taxes. Wind pays a proportionally larger share in property taxes because more facilities must be erected to generate equivalent power. Below are state-specific results. Some notable differences are:

- Prices for fossil fuels are assumed to be higher in Michigan than in the other states, and capacity factors are lower. This leads to an increase in overall capacity needed and in dollars spent in Michigan.
- Based on actual data for proposed new plants, installed cost for a coal plant is much higher in Arizona ($2000/kW) than in Colorado ($1450/kW), which makes a considerable difference. Coal benefits Arizona's economy more than Colorado's. This could be due to varying pressures for new environmental equipment or state policies.

- Even though a state may not have natural resources to generate electricity, if it has a large resource (coal or gas) transportation industry, like Michigan, the economy can benefit significantly from the imported resource.

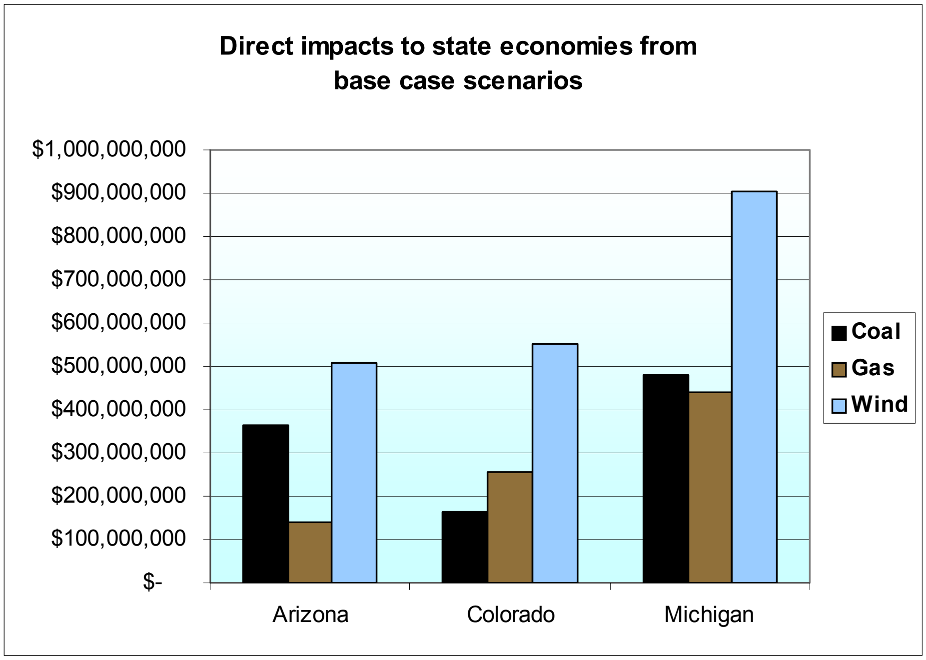

Figure 12. Base case scenarios of economic impact from new power plants in Arizona, Colorado, and Michigan

Individual State Results

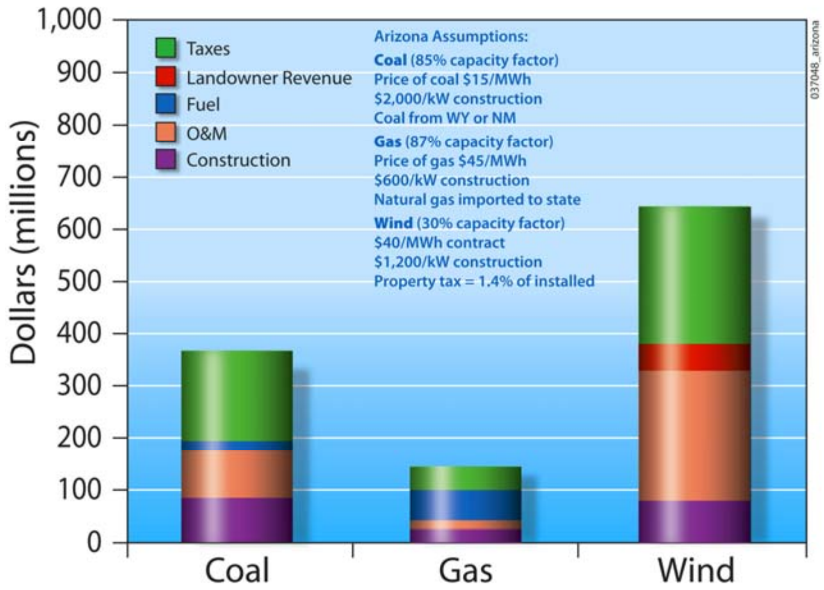

Figure 13. Dollars spent on new electricity generation from coal, gas, and wind in Arizona
Note: The fuel components for coal and natural gas are prices paid by the power plant for fuel. The contract price listed for wind is the amount the plant owner can charge for the output of the wind farm and is used to calculate landowner revenue.

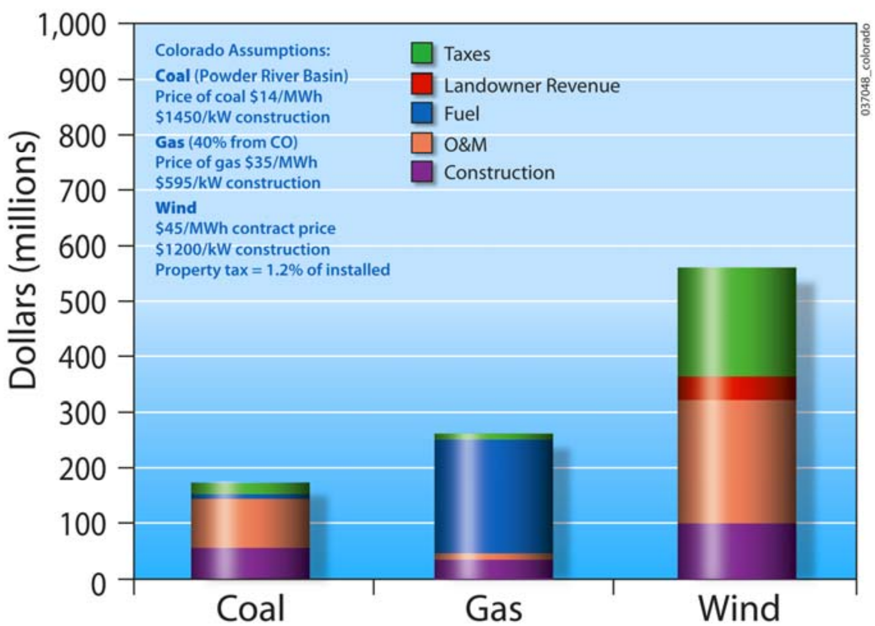

Figure 14. Dollars spent on new electricity generation from coal, gas, and wind in Colorado

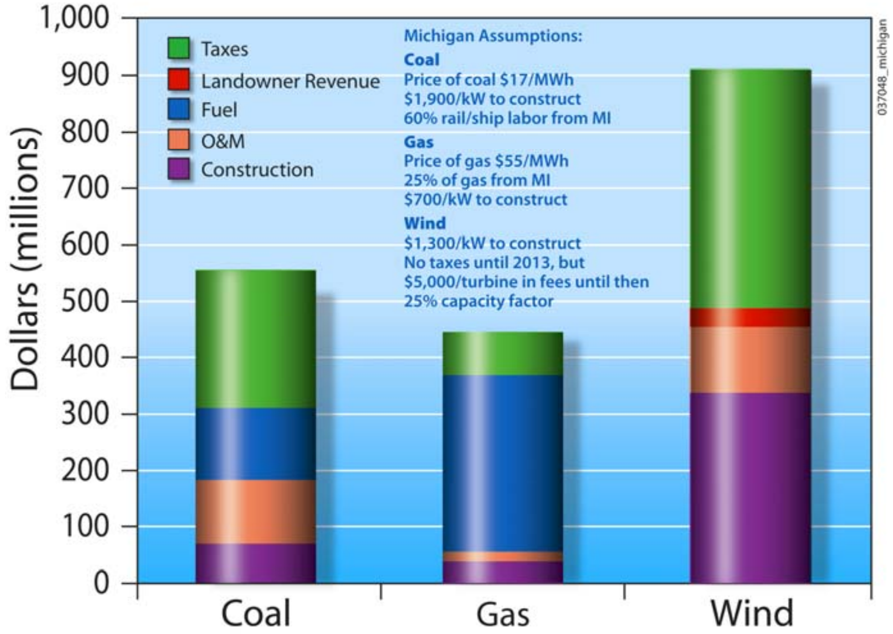

Figure 15. Dollars spent on new electricity generation from coal, gas, and wind in Michigan

Colorado Results and Specific Sensitivities

As Figure 14 and Table 2 indicate, the average wind plant would bring more dollars to the Colorado economy than coal or gas plants, provided that the wind plant hires some in-state labor and uses some Colorado materials (e.g., concrete). This result is partially due to the large percentage of in-state workers (20%-46%) for construction, the even larger percentage of workers during the operations phase (90% in state), and the size of the project (680 MW versus 270 MW or 280 MW). A large part of the wind spending is also due to county property taxes. In other states, wind plant owners have negotiated partial exemptions from taxes, but this has not occurred in Colorado. However, coal and gas plants have historically been at least partially exempt from property taxes.

Table 2. Dollars Spent in Colorado from 270 MW New Energy Output over 20 Years

	Coal	Gas	Wind
Construction	$47,705,000	$24,458,963	$91,392,000
O&M	$90,125,000	$11,054,118	$223,040,000
Fuel	$8,756,496	$210,442,575	$ -
Landowner Revenue	$ -	$ -	$43,500,000
Taxes	$17,271,121	$8,406,060	$193,228,800
* Construction times vary for each resource: coal 5 years, gas 2 years, wind 1 year			

When in-state versus out-of-state spending is calculated, it becomes apparent that a new gas plant would produce more total spending but that most of the money would be sent out of state. Each generating source spends more out of state than in Colorado, regardless of the fuel source or tax negotiation. Figure 16 shows in-state and out-of-state spending for new power generation. As previously noted, this project does not examine price impacts to consumers but considers overall state economies. Clearly, if consumers have to spend more of their income on electricity, they will have less to spend on other goods and services. When making an informed decision about new power generation, a policymaker should include consumer pricing and other issues, along with information from studies like this one.

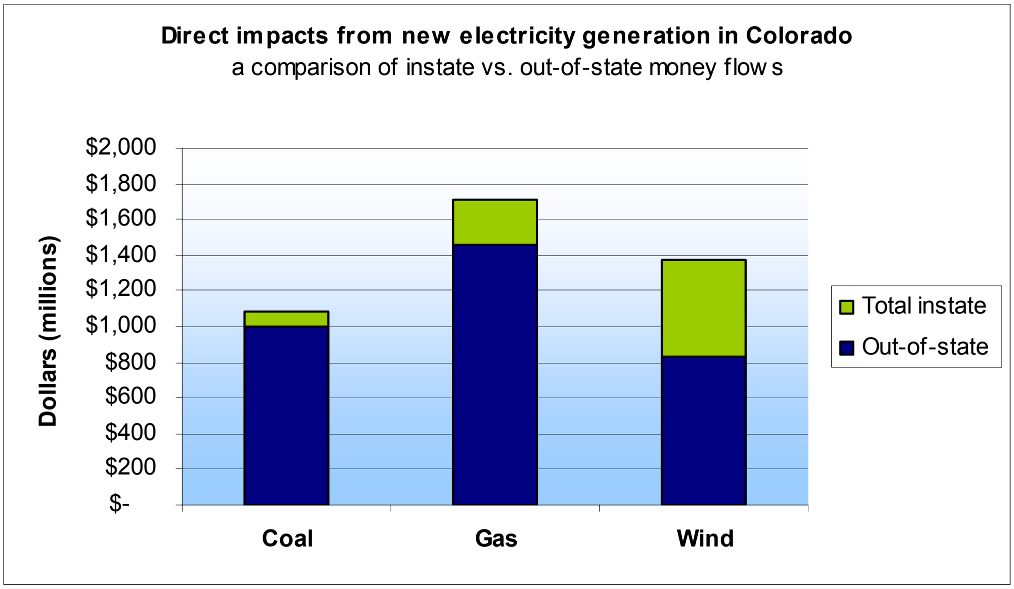

Figure 16. Colorado vs. out-of-state impacts from new electricity generation

The following series of figures and tables show individual energy-generation resources broken down by component for the Colorado economy. In a forthcoming publication, these figures will be presented for Arizona and Michigan and will be located in assumptions sections specific to each state. The figures show direct economic benefits to the economy from each resource, given the most likely scenario. I-shaped bars represent uncertainty ranges in the data. Further explanation of sensitivity analyses for particular energy resources may be found in Sensitivity Scenarios.

Table 3 and Figure 17 show direct economic benefits to Colorado for a coal plant with sensitivity bars. The biggest range of uncertainty is caused from the plant using Colorado coal, which is unlikely.

Table 3. Direct Economic Benefits from New Coal Generation

COAL		Range	% CO*	%CO range
Construction labor 25%	$1,450/kW	$1300 -$1800/kW	17%	7%-37%
Construction materials 75%	$1,450/kW	$1300 -$1800/kW	5%	0%-15%
O&M labor 65%-75%	$25/kW	$8 - $27/kW	65%	25%-95%
O&M materials 25%-35%	$25/kW	$8 - $27/kW	63%	60%-93%
Fuel	$14/MWh	$13 - $18/MWh	0%	0%-56%
Mining	40% of fuel	40% - 50%	0%	0%-56%
Railroad	60% of fuel	50% - 60%	10%	0%-10%

*Money spent in Colorado

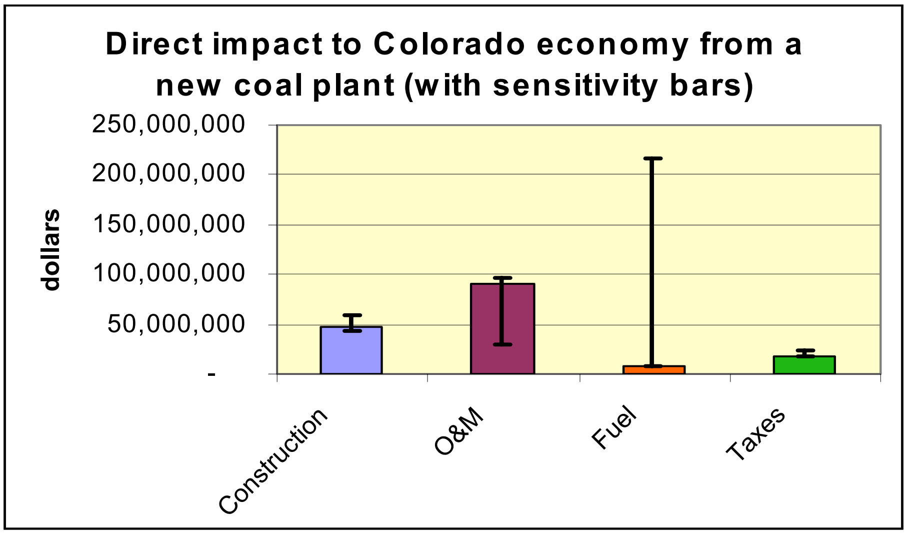

Figure 17. Direct impact to Colorado economy from a new coal plant, with uncertainty bars

As shown in Tables 4 and 5 and Figures 17 and 18, coal and gas have high uncertainty in their fuel categories. Almost all of the uncertainty for natural gas is related to gas price estimates. The price range is from $30/MWh to $55/MWh. Prices as high as the top scenario ($55/MWh) are unlikely but possible in Colorado power plants' long-term contracts. Coal's uncertainty bar has such a large range because of the chance that 100% of the coal may come from Colorado, as opposed to the assumed 0%.

Table 4. Direct Economic Benefits from New Natural Gas Generation

GAS		Range	% CO*	Range % CO
Construction labor 25%	$595/kW	$550-$800/kW	40%	15%-60%
Construction materials 75%	$595/kW	$550-$800/kW	5%	0%-10%
O&M labor 75%	$10/kW	$8-$19/kW	25%	16%-45%
O&M materials 25%	$10/kW	$8-$19/kW	5%	10%-45%
Fuel	$35/MWh	$30-$55/MWh	40%	10%-66%
Extraction	80% of fuel	-	15%	5%-20%
Pipeline	20% of fuel	-	0%	0%-10%

*Money spent in Colorado

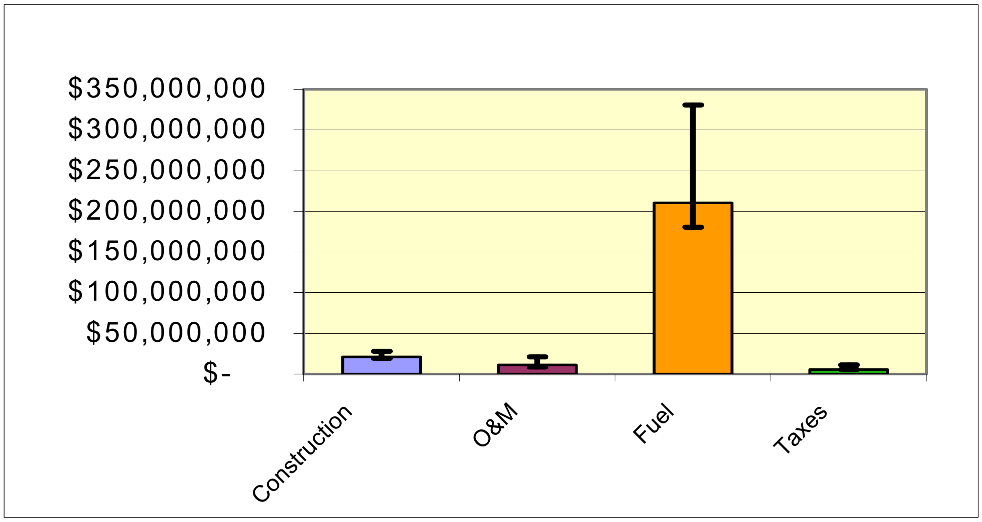

Figure 18. Spending in Colorado for a new natural gas plant, with uncertainty bars

Table 5. Direct Economic Benefits from New Wind Generation (635 1.5-MW turbines)

Wind		Range	% CO*	Range % CO
Construction labor 10%	$1,200/kW	$1100-$1500	40%	20%-46%
Construction materials 90%	$1,200/kW	$1100-$1500	8%	6%-10%
O&M labor 70%	$20/kW	$10-$27/kW	90%	80%-99%
O&M materials 30%	$20/kW	$10-$27/kW	20%	5%-33%
Landowner revenue	3.5% of revenue	$3000-$5,000	100%	-
Property taxes	1.2% of project	0.9% - 3%	100%	-

*Money spent in Colorado

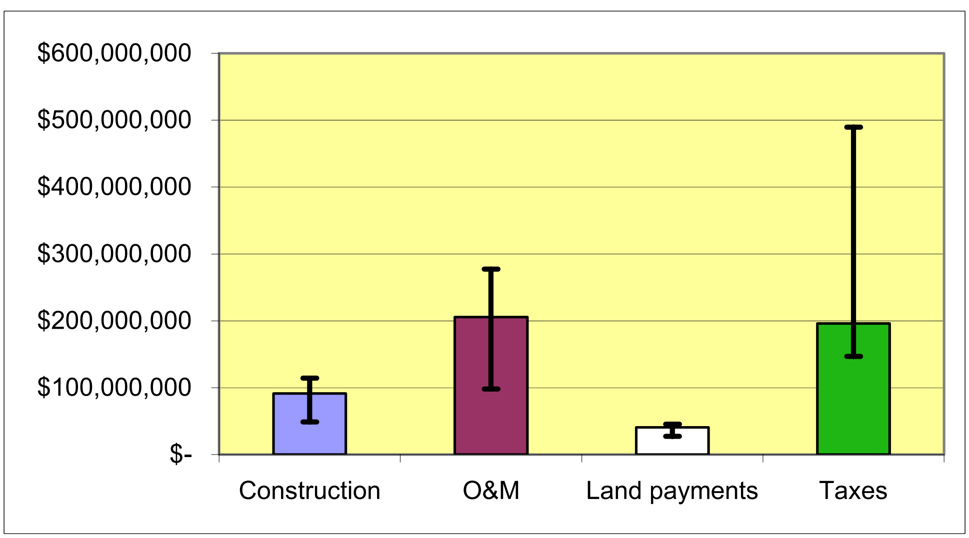

Figure 19. Spending in Colorado for a new wind power plant, with uncertainty bars

Table 5 and Figure 19 show direct economic impacts for building new wind power. For wind, the component with the most uncertainty is taxes. Typically, taxes are assumed to be between 0.9% and 3% of total installed costs. The large range in dollars per kilowatt for construction between $1100 and $1500, along with the property tax percentage, leads to the sizable range in construction results. O&M is considered by some developers to be 60% labor and 40% parts, while most consider that the labor accounts for between 70%-80%. Landowner revenue can fluctuate between $3,000 and $5,000 per turbine per year (based on the assumed 1.5-MW turbine size).

The data show significant differences and implications between wind and fossil fuels in the category of property taxes in all states. Coal and gas plants owned by utilities are often but not always exempt from property taxes in Colorado, and the utility might negotiate a deal with local communities by paying for county improvements such as a library, school, or police station. Such negotiated costs cannot be captured in a study of average power plant benefits because they are unique to each deal made between the utility and county. It should be noted that these negotiated donations from utilities would also benefit communities and, therefore, the Colorado economy. The County presumably finds the short-term gain of the payment, in addition to jobs created by the new power plant, worth the exchange for property taxes. However, the utility makes a one-time payment to the county, whereas property taxes would be collected over the lifetime of a power plant.

In addition to the consideration of tax exemption, wind plants purchase or lease a considerably larger piece of property for the same energy output as gas and coal. The State of Colorado does not base property taxes on the actual amount of space utilized by wind turbines but by the value of the installed turbines. The installed turbine value is greater than the value of a gas or coal plant because so many wind turbines are needed to generate the same amount of electricity. This is significant in rural communities because the county divides tax revenues to pay for services such as schools and roads. Wind plants also cause an increase in a landowner's property values.

Sensitivity Analyses

Following is an exploration of some uncertainty scenarios or sensitivity analyses discussed above. In the most likely scenario, coal for a new Colorado coal plant will come from Wyoming. Figure 20 shows a scenario in which all of the coal comes from Colorado. With everything else remaining equal, coal will not bring as much spending to Colorado as wind (but more than gas), and spending will be significantly higher than it is with out-of-state coal.

As mentioned, another uncertainty is the origin of Colorado's natural gas plants. At the highest, according to most natural gas experts we spoke with, 66% of the natural gas will come from Colorado. With everything else remaining in the base case, here are the results for a higher percentage of gas from within the state.

We mentioned the differences between results without an applied discount rate and a discount rate of 5% or 7%. In Figures 22 and 23 below, we see the results for Colorado coal. In forthcoming versions of this paper, we will display other components and resources with applied discount rates. When a discount rate is applied, the impacts are naturally smaller.

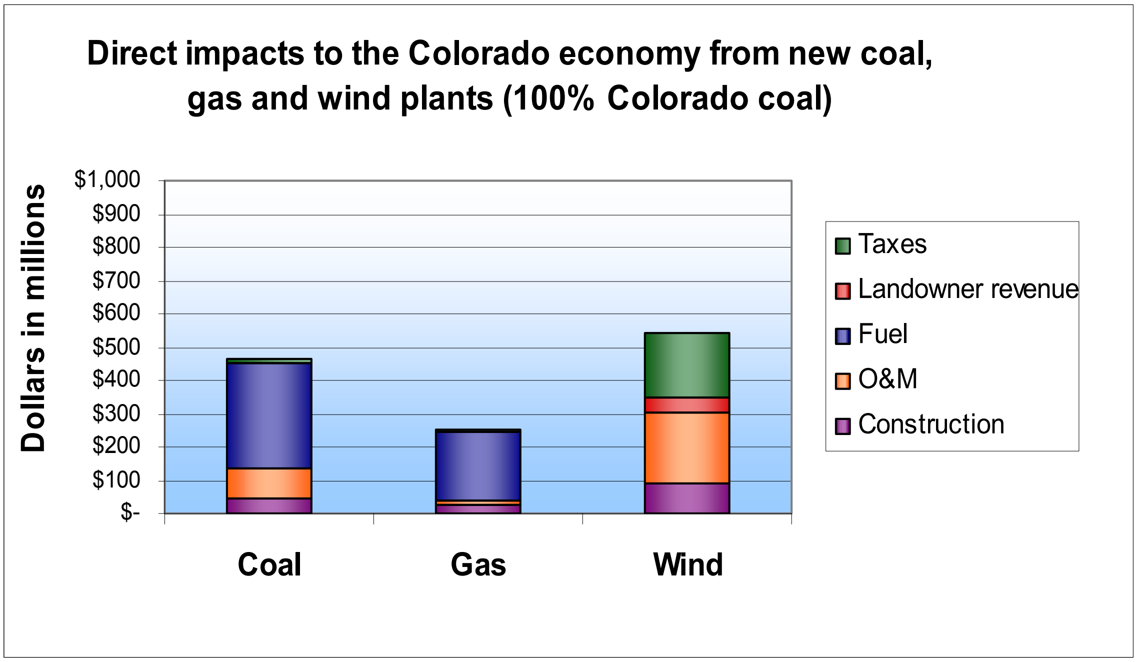

Figure 20. Sensitivity scenario: 100% of coal is from Colorado mines

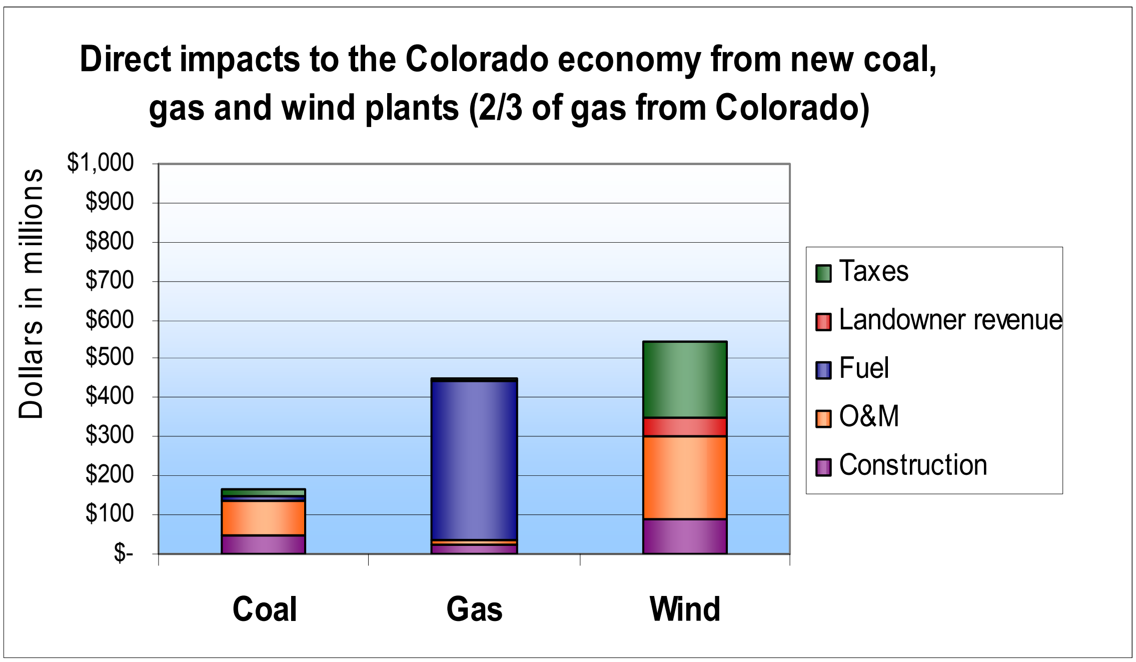

Figure 21. Sensitivity scenario: 66% of natural gas is from Colorado

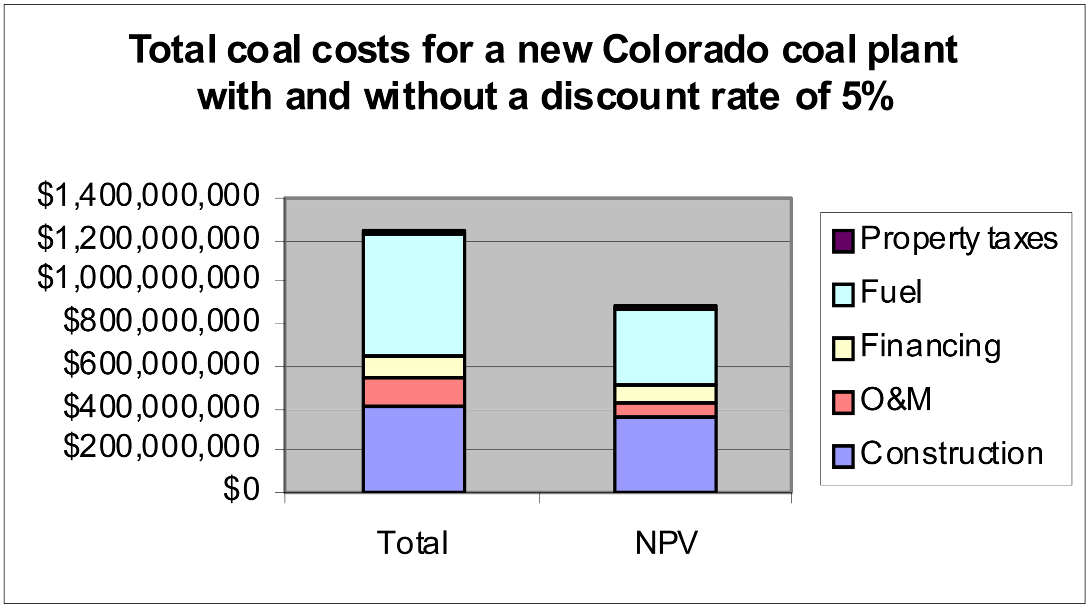

Figure 22. Total impacts (in and out-of-state) for a new Colorado coal plant, with and without a discount rate of 5%

Note that construction and financing in both cases remain relatively unchanged because construction occurs within the first 5 years, and we assume 10 years for financing.

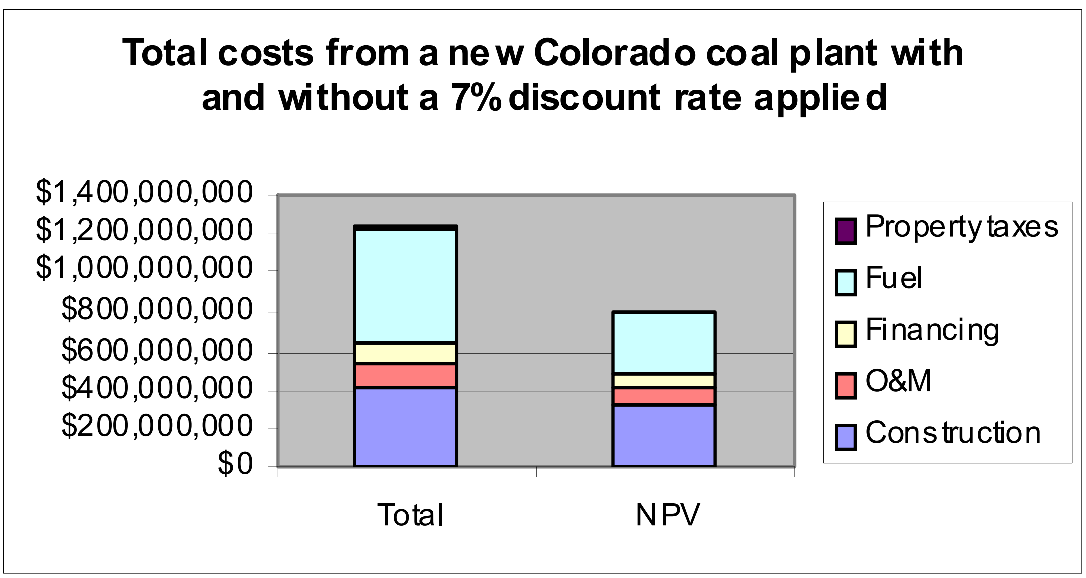

Figure 23. Total impacts (in-state and out-of-state) for a new Colorado coal plant, with and without a discount rate of 7%

Lessons Learned

When conducting a "follow the money" study in other regions, it will be helpful to draw on lessons from this report to save time and frustration for researchers and interviewees. Methods detailed here are transferable to other projects that explore economic questions about which energy resource to build next.

As with any research project, the first step is to define the required data and obtain contacts for that information. Local data are almost always preferred, but when it is not available, national averages may be sufficient. For example, is it important to have precise railroad data for your state, or can you use national averages? We carefully chose components of this research and selected the most economically significant benefits to represent graphically. Unfortunately, many developers consider this type of information proprietary due to competitive forces in the marketplace. Many costs and benefits of electricity generation are proprietary and cannot be released. Some dollar values for this project were indeed confidential and were given to us with the understanding that we would use aggregate numbers and not mention sources.

Information for labor and equipment costs was obtained through much deliberation from key industry contacts. In addition, we used JEDI (Goldberg et al. 2004), which was especially helpful for cost breakdowns. For overall costs of fuel and O&M, we referred to power plant operating companies and BaseCase. For specific numbers, such as the labor component of natural gas transport, we spoke with industry representatives (e.g., natural gas pipeline manufacturers). We obtained manufacturer names by speaking with people at existing utility power plants. We did not add environmental or political costs and benefits, which would be much harder to quantify than direct economic benefits. We recommend including only operations and maintenance costs – not including "all-in," or costs such as taxes or landowner revenues, which should be broken out separately.

To obtain financing information, we initially contacted utility employees, who were generally unable to answer our requests. Eventually, we learned from other energy experts that financing for all three power sources is most likely an out-of-state impact, with no money flowing into the Colorado economy. Some small wind projects may be financed in-state, but usually financing comes from out of state, unless the plants in question were in New York or Massachusetts, where large lending institutions are located. We recommend contacting in-state independent banking associations. These organizations may know about power plant financing. Additionally, municipalities and electricity cooperatives might have helpful information and/or contacts. See the Components section of this report for other financing options.

Tax information should be sought first from counties, which is where most property tax is collected. Obtain mill levies and the procedure by which property taxes are assessed. If county taxes are assessed by the State, researchers will likely need to combine information from state assessors with details from county assessors and treasurers. The Public Utilities Commissions, in this case, did not provide data for any categories analyzed by this project, but we do recommend interviewing them in case they are able and willing to help. Researchers working with the Public Service Commission in Michigan, for example, were extremely helpful.

It is important to remain "resource neutral" when interviewing so that all parties feel comfortable providing information. It is also crucial to state assumptions early, so that they are clear in the project results. More important, stating assumptions early will ensure that they are clear to researchers throughout the project. Project boundaries and scope are closely linked to assumptions.

Conclusion

The addition of a new generating facility equivalent to a 270-MW natural gas plant will have direct economic benefits for a state's economy. If the fuel of choice is coal or gas, impacts to the economy may be fewer from coal or gas than if the fuel is wind. But natural gas also has a significant impact to the economy if a portion of the natural gas comes from within the state and is transported by state industry. If a big portion of the labor for coal extraction or coal transportation comes from within the state, then coal will bring significant spending to the state (however, according to our assumptions, not as much as wind power would bring for the equivalent amount of energy produced).

Energy planners and the energy industry should consider studies like this when deciding where to site a power plant and which benefits can be offered to local communities from the addition of a new power plant. This information is also valuable in making state- or regional-level policy decisions about energy resources and state-sponsored incentives, such as renewable portfolio standards or energy incentives.

Additional research is needed on this topic, especially on county and state taxes and on project financing. It is likely that tax impacts are so specific to each case that they will have to be evaluated on a case-by-case basis. This study did not include externalities such as air pollution, effects to the local environment, or payments to the state for black lung disease. Another study might include such costs. Future work might also address the difference in consumer rate impacts associated with different plants.

Acknowledgments

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Personal Communication

Some personal communication for this research is considered confidential. Agencies, companies, and organizations allowed the author to use their data in aggregate only. In some cases, the author is able to list company or organization names, but not employee names. Personal communication for this project included data and advice from the following:

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Basin Electric Power Cooperative
Boulder County Treasurer's Office
Colorado Mining Association
Colorado Oil and Gas Commission
Colorado Rural Electric Association
Craig Cox
Dale Osborn, DISGEN Systems
Energy Intelligence Group, Inc. for pipeline capacity information
EnXco, Inc.
La Plata County Assessor's and Treasurer's Offices
Mark Walker, State Division of Taxation
Marshall Goldberg, MRG & Associates
Michael Milligan, National Renewable Energy Laboratory
Deb Meyer, Colorado Office of Taxation, State Division of Property Taxation
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14. ABSTRACT *(Maximum 200 Words)*
With increasing concerns about energy independence, job outsourcing, and risks of global climate change, it is important for policy makers to understand all impacts from their decisions about energy resources. This paper assesses one aspect of the impacts: direct economic effects. The paper compares impacts to states from equivalent new electrical generation from wind, natural gas, and coal. Economic impacts include materials and labor for construction, operations, maintenance, fuel extraction, and fuel transport, as well as project financing, property tax, and landowner revenues. We examine spending on plant construction during construction years, in addition to all other operational expenditures over a 20-year span. Initial results indicate that adding new wind power can be more economically effective than adding new gas or coal power and that a higher percentage of dollars spent on coal and gas will leave the state. For this report, we interviewed industry representatives and energy experts, in addition to consulting government documents, models, and existing literature. The methodology for this research can be adapted to other contexts for determining economic effects of new power generation in other states and regions.

15. SUBJECT TERMS
wind energy; economic development; economic impacts; coal; natural gas; Arizona; Michigan; Colorado; power plants

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