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Coal Plants in Transition: An Economic Case Study

Natural Capitalism Solutions

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Contents

1. Summary

Natural Capitalism Solutions has analyzed the value created by phasing out an existing coal plant, and has demonstrated that the electricity generated and jobs provided by a coal-fired power plant can be shifted cost-effectively, by reinvesting the savings and credits from phasing out the coal plant into efficiency improvements and renewable energy technologies.

The timeline for implementing these solutions depends almost entirely on various triggering events such as the value of reduced carbon and sulfur emissions via some sort of market exchange, the price of water, government regulations, court rulings, and the amortization schedule for repaying the original financing of the plant. As the cost of carbon rises, existing coal plants can be phased out more quickly. Using the example of the 17 terawatt hours (TWh) of electricity produced by Navajo Generating Station in 2005, this report compares various scenarios, including low, medium, and high values for revenues and investments. At "medium" level assumptions for revenues and required investments, such as $35 per ton of CO2 equivalent, and $630 per acre-foot of water, this analysis shows that it is cost-effective to phase out an existing coal plant within one year, without any reduction in end-use services or jobs, resulting in an annual revenue surplus of $157,588,290.

Table 1: Revenue Streams

Potential future revenue streams from phasing out existing coal plant (NGS) **($/year, nominal phase out year $)**	**Low**	**Medium**	**High**
Annual value of SO_2 credits	$769,011	$6,507,015	$14,197,124
Annual value NO_x credits	$1,277,303	$8,941,118	$26,823,353
Annual value CO_2 credits	$68,122,800	$551,368,913	$1,072,934,100
Annual resale value of water	$3,439,009	$16,538,745	$36,752,767
Annual saved fuel costs	$288,785,833	$449,610,480	$830,246,625
Premium for Green Electricity	$163,494,720	$299,740,320	$435,985,920
Future revenue streams in $/year	$525,888,675	$1,332,706,590	$2,416,939,889

Table 2: Investments in Efficiency and Renewables

Annual investment to shift annual average production of NGS to efficiency and renewables	**%**	**Low***	**Medium**	**High**
Efficiency	20%	$34,061,400	$51,092,100	$102,184,200
Wind	35%	$298,037,250	$476,859,600	$596,074,500
Solar Photovoltaic	5%	$42,576,750	$68,122,800	$102,184,200
Concentrating Solar – Power Tower	30%	$306,552,600	$459,828,900	$664,197,300
Biomass	5%	$42,576,750	$76,638,150	$110,699,550
Geothermal	5%	$34,061,400	$42,576,750	$68,122,800
Total	100%	$757,866,150	$1,175,118,300	$1,643,462,550

*Note: "Low" scenario assumes $.01/kWh for efficiency improvements and other optimistic valuations.

Summary

Annual surplus ($/year)	Medium revenue - Medium investment
Total	$157,588,290

In summary, deducting the medium estimate for required investment, from the medium projection for total revenue from phasing out the coal plant early results in net revenue of $157,588,290.

The following analysis (Section 4, page 12, et seq.) includes financial estimates of the investments required for efficiency improvements and renewable sources, as well as the benefits derived from eliminating the costs of coal, CO_2, SO_x, NO_x, water, health, and other externalized impacts, and also a sample estimate of NEPA-type life cycle accounting for various other impacts. The analysis also includes brief discussions of impacts on jobs and the "economic multiplier" effect provided by investing revenues at the local level, rather than sending the money collected from utility bills out of the region to pay for coal.

This analysis is based specifically on the profile of Navajo Generating Station (NGS), in Arizona. However, the accompanying electronic "Dashboard Calculator" spreadsheet provides a tool to calculate the benefits and return on investment for phasing out any of the 613 existing U.S. coal plants. The dashboard allows users to determine how fast the need for electricity provided by a coal-fired power plant could be eliminated or obtained from efficiency improvements and renewable sources in cost- effective ways. These calculations show how stakeholders can receive greater benefits from phasing out a coal plant, than from operating it in a carbon- and water-constrained world.

The Dashboard Calculator can be downloaded from the web at:

www.natcapsolutions.org/coal/calculator.xls

Although it is difficult to assign health impacts to any individual coal plant, the combined particulate emissions of mining, transporting, and burning coal nationwide result in 23,600 premature deaths, 38,200 heart attacks, 554,000 asthma attacks, 21,850 hospital admissions, 26,000 emergency room visits, and 3,186,000 lost work days in the U.S., which, taken together, cost the country between 18 and 84 billion dollars each year.

By contrast, investing in efficiency improvements and renewable sources of energy eliminates these health impacts, while creating new jobs and related economic multipliers, while simultaneously increasing the resilience and security of our national energy system,

Based on this analysis, Natural Capitalism Solutions proposes that efforts to meet America's energy needs focus on restructuring economic assumptions, to recognize the value of eliminating the pollution, health costs, and economic impacts of existing coal plants.

2. Scope and Limitations

Intended Audience

This report is intended for a general audience -- people not particularly trained in economics or utility finance. Its purpose is to provide general, "thumbnail," financial estimates of the benefits associated with eliminating the costs associated with coal fired power plants as well as accompanying estimates of the investments required to shift the coal-based jobs and services to efficiency improvements and renewable sources of energy.

Limitations

Though based primarily on statistics derived from Navajo Generating Station (NGS), this analysis is not designed to provide in-depth economic calculations for NGS or any other individual plant. Rather, the present analysis provides a "proof of concept" approach, to demonstrate one or more possible scenarios under which it might be cost-effective to shift the jobs and services of an existing coal plant to more profitable and less-harmful options.

No attempt has been made in this report to describe net present values, annual dollars, levelised costs, nominal costs, or any of the other, more complex economic calculations that would be required to apply these options to a specific coal plant. In addition to being restricted by budget limitations, after consideration, the present authors concluded that these more intricate calculations would take the presentation beyond what is required to demonstrate the possibilities under consideration. Calculations of such additional items as social costs and discount rates are controversial and would take the analysis well beyond proof of concept.[1] The details and intricacies of applying the thesis to an individual plant will require extensive, site- and region-specific calculations that would not be broadly applicable to more than one example.

Similarly, other than an illustrative, imaginary example in the accompanying electronic Dashboard Calculator, this report does not include analysis of the specific load capacity, spinning reserves, time of day, and/or demand profiles that would be required to match efficiency improvements and renewable sources of supply to the particular profile of an individual coal plant. Utility planners, who are more familiar with the intricacies of utility finance are better qualified, better equipped, and better financed to undertake these calculations.

This report assumes that any follow-up proposal to phase out a specific coal plant will require additional analysis, to calculate the exact ratios and applicability to the unique employment and energy profile of the individual coal plant and region.

Like a canary in a mineshaft or a rainbow after a storm, this report is intended to provide warning signs and "snapshot images" of what might be possible.

Although the calculations contained in this report are sufficient to demonstrate the cost effectiveness of shifting coal plant services to increased efficiency and renewable sources of supply, deeper, more extensive and expensive analysis will probably be required, to examine the intricacies of specific opportunities, as well as to correct any inadvertent errors contained herein.

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[1] Holladay, J. Scott and Jason A. Schwartz. *The Other Side of the Coin: Economic Benefits of Climate Legislation.* Institute for Policy Integrity, New York University School of Law. September 2009. Viewed September 25, 2009 at: http://www.policyintegrity.org/documents/OtherSideoftheCoin.pdf

3. Background and Introduction

With the success of national efforts to discontinue construction of proposed coal fired power plants,[2] it was only logical to begin to ask questions about ways to phase out the remaining, existing coal plants. This report is the outgrowth of prior work, in which Paul Sheldon, the primary author of this report worked with another team of consultants to document and analyze economic and energy alternatives to the proposed 1,500 MW Desert Rock coal fired power plant, near Farmington, NM.[3] Because the Desert Rock report successfully documented the feasibility of providing for the same end-use needs, in less damaging but still cost-effective ways, the current analysis of the cost effectiveness of transitioning existing plants was developed as a next step.

Mohave Generating Station, in Laughlin, NV, was mothballed and subsequently scheduled for destruction due to its negative impacts on human health from particulates, negative impacts on visibility and haze in the Grand Canyon, and the high cost to remedy these impacts. The planners of this current analysis selected the nearby Navajo Generating Station as a likely next candidate, on which to base the analysis of the cost-effectiveness of transitioning existing coal plants.

[2] http://www.reuters.com/article/GCA-GreenBusiness/idUSTRE5684UN20090709
[3] Ecos Consulting. *Energy and Economic Alternatives to the Desert Rock Energy Project.* Dine' CARE, Farmington, NM. 2008.

Navajo Generating Station (NGS)

Service Area and Use

In 1969, as soon as construction was completed at the now defunct Mohave Generating Station in Laughlin, NV, the plant's builder, Bechtel transported its crews to Page, AZ, to begin work on the $650 million Navajo Generating Station (NGS).

Located within the Navajo Nation in Coconino County, basic construction of NGS was completed by Bechtel in five years, and Bechtel brought the first of NGS' three, 750-MW units on-line in 1974. By 1976, two years later, the plant was operating at its full 2,250-MW capacity, burning up to 25,000 tons of coal per day, as it dispersed electricity across the Desert Southwest region marketing area to each of its six principal owners.

Five separate public utilities in Arizona, California and Nevada contract for approximately 75 percent of NGS' electricity, much of which works to satisfy the peak-load demands of the metropolitan areas of Los Angeles, Phoenix, Tucson, and Las Vegas. Although no single utility is exclusively dependent on NGS to satisfy peak load demands, each is reliant on the plant at least to some degree, as shown in the Arizona Public Service profile below:

Customer	Percentage	MW
U.S. Bureau of Reclamation	24.3	546.75
Salt River Project (SRP)	21.7	408.23
Los Angeles Department of Water and Power	21.2	477.00
Arizona Public Service Company	14.0	315.00
Nevada Energy	11.3	254.25
Tucson Electric	7.0	168.75
	99.5	2,239.00

While public and commercial utilities have contracted for the majority of NGS electricity, the U.S Bureau of Reclamation has the largest single share, with 547MW for the Central Arizona Project (CAP) and its 336-mile network of canals driven by electric water pumps. The primary catalyst for Phoenix and Tucson's "desert bloom," the CAP carries water from the Colorado River over three mountain ranges, effectively rendering it the most expensive and subsidized water on the planet.[4]

Despite this fractional ownership, for practical purposes, the Salt River Project (SRP) is the exclusive plant operator, and is thus the sole entity with first-rights to surplus energy generated by

[4] Niles, Judith. "The Black Mesa Syndrome: Indian Lands, Black Gold." Orion Magazine. Summer, 1998.

NGS. The other five owners receive their contracted-for shares as required, but if surpluses exist, they go first to SRP, then subsequently to other markets.

Although it is not true that old coal plants never die, they are often serviced, reconditioned, and/or upgraded, to continue operating long past the repayment of their construction costs and long past the initial contract terms for the sale of electricity to specific entities. Many coal plants in the United States have been operating for decades, and in some cases, since the 1920s or '30s. The Los Angeles Department of Water and Power announced in the spring of 2009 that it would not renew its contract to purchase coal fired electricity from NGS, once the current contract expires in 2019,[5] but the plant's operators could locate other buyers, and could continue operating the plant for many decades. Similarly, although the current permit to mine and supply coal ends in 2026, it could be renewed in 5-year increments.[6]

Thus, NGS does not have a fixed end of plant life.

Understanding the Variables

As is noted below, in the section titled Other Externalized Impacts, many costs of operating coal plants seem to be accepted without comment by rate payers, who must pay the direct or indirect costs of sinking groundwater, toxic ash disposal, clean up, steadily increasing fossil fuel prices, health costs of asthma and heart disease, mercury poisoning, and less-quantifiable items, like reduced property values, environmental injustice, loss of archeological heritage, forest degradation, and loss of habitat for fish and other wildlife. Investing in efficient use of renewable sources of energy eliminates most of these "externalized" costs. Essentially all such costs will eventually be passed on to rate payers in one form or another, including expensive solutions such as installing catalytic reduction controls to reduce NO_x emissions (estimated at $400MM for NGS, in addition to the large investment for sulfur scrubbers installed in 1999, which was subsequently paid back by selling sulfur credits[7]); other pollution controls; increases in coal costs; hauling and mining costs; and coal contracts. Although the general public has remained largely silent about these burdens, the authors of this report have noticed many indications that a choice point is near. Such a choice point could be brought on by any of the following "triggering events" or "wild cards":

[5] ClimateLA Program Document, p. 14, viewed 8/19/2009 at http://www.lacity.org/ead/environmentla/pdf/ClimateLA%20Program%20document%2012-08.pdf
[6] http://www.wrcc.osmre.gov/WR/BMFinalEIS/VolumeI-Front.pdf, p. ES9.
[7] http://www.epa.gov/compliance/resources/cases/civil/caa/srp-infosht.html

Triggering Events and Wild Cards

Many events could create conditions under which the scenarios described in this report could become cost-effective, such as:

- Breakthroughs in solar photovoltaic technologies that achieve parity with coal pricing -- "Moore's Law" appears to apply to solar costs;
- Costs of wind continue to drop, leading more states to prioritize wind over coal, as is happening in WY, MT, and NV;
- Radical drops in natural gas prices, and/or discovery of large, new natural gas supplies make coal too expensive;
- Future costs of pollution control equipment are high enough to consider them a significant factor, in combination with other costs or investment options, that makes phasing out the coal plant cheaper than reducing or mitigating the pollution impacts;
- Federal government or regional collaboration provides independent financing and construction of transmission capacity that allows greater access to national grid for remote wind and solar resources;
- Federal legislation and/or carbon trading procedures allow both carbon credits for reduced emissions from coal AND sale of renewable energy credits for providing non-polluting sources of supply;
- Climate catastrophes, like Katrina, fires in Greece, loss of temperate forests, melting ice caps, inland hurricanes, etc. capture public attention;
- China decides to stop mining coal and instead begins to purchase on the world market[8];
- Estimates of available/accessible Powder River Basin coal supplies prove too high, causing the price of coal to rise rapidly;
- Rigorous enforcement of AB32 in California leads to similar legislation in other states;
- Regional Greenhouse Gas Initiative (RGGI) and California Climate Action Registry (CCAR) are replicated in Midwest and other regions;
- Federal and/or state subsidies, incentives, or loan programs, such as tax credits, low interest loans, revolving loan funds, low cost guarantees, and other innovative financing options lead to cost parity with coal;
- Federal interpretations or court rulings phase out mountain top removal mining;
- Federal and/or state governments provide more rigorous enforcement of existing mine safety laws;
- Federal administration or courts provide more rigorous enforcement of the Clean Water Act;
- Federal administration or courts provide more rigorous enforcement of the Clean Air Act;
- EPA retains authority to regulate CO2 and does so;
- Civil disobedience becomes more widespread, as in Europe, with people blocking mines, trains, fuel cycle components, etc. [*Authors' note: This is neither a desirable, nor a recommended option, but there have been increasingly severe actions opposing coal in other countries, and in the U.S. as well*][9]; or
- More severe water shortages increase the price of water above $1,000/acre-foot.

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[8] http://www.ft.com/cms/s/0/1c744c2c-9009-11de-bc59-00144feabdc0,dwp_uuid=9c33700c-4c86-11da-89df-0000779e2340.html
[9] a) http://www.sourcewatch.org/index.php?title=Nonviolent_direct_actions_against_coal:_2009;
b) http://www.greenpeace.org/international/press/releases/greenpeace-joins-polish-demon; or
c) http://www.greenpeace.org/international/press/releases/ninety-greenpeace-activists-ar.

Peak Load or Base Load; Coal or Renewables What Is The Capacity?

An important point to note, when addressing the use of a coal plant, is whether the electricity is being used to meet peak loads, at the times of day and times of year when the demand for electricity throughout the entire system is at its highest, or base load, when demand is at its lowest.

As is the case with many coal plants around the country, NGS provides base load power, year round. In most areas of the country, coal plants are primarily used for base load power.

However, both wind and concentrating solar have been shown to provide base load reliability through "portfolio" management and storage, such as underground pump storage and compressed air, thus removing the traditional assertion that they are only applicable to meet intermittent, peak load demands. In addition, if used at peak times of day and peak times of year, electricity from renewable sources can be sold at a premium, both for "green" electricity, and peak "time of day" prices as high as $0.19/kWh.[10]

Commitment to Efficiency and Renewable Energy?

Although many, if not most utilities are investing in what they consider to be substantial commitments to increase efficiency and renewable sources of electricity, by comparison to what is possible, most such commitments are token in nature – meeting the minimum quota required by law. Commitments by most utilities do not represent what is technologically and economically possible, as is detailed in the section below on energy efficiency.

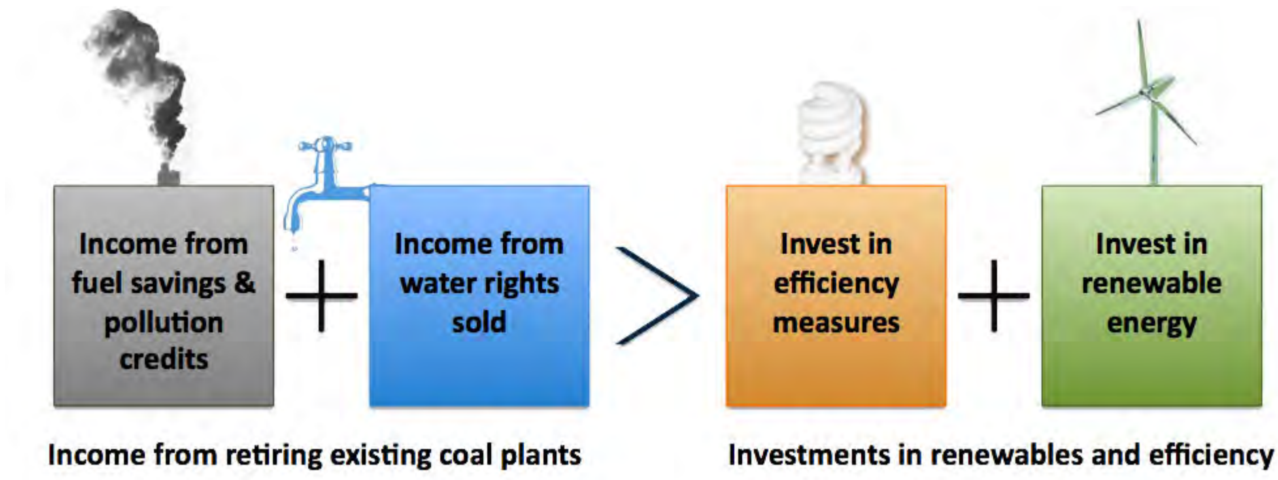
Also, with demand forecasted to be at least 6% below projections for several years to come, now is an ideal time for utilities to consider taking coal plants offline and directing the resulting credits towards investments in further efficiency and renewable sources of energy.[11]

This analysis concludes that greater efficiency is possible, which will buy time, and that more aggressive commitments to regionally appropriate, renewable sources of energy can bring additional base load capacity online faster and more cost effectively than building new coal plants, or in some cases, than operating existing plants, such as Navajo Generating Station.

[10] http://planetgreen.discovery.com/home-garden/renewable-energy-nyc.html
[11] http://www.forbes.com/2009/08/21/coal-utilities-rail-markets-equities-commodities.html

Findings

The findings presented in this report were derived in a fairly straightforward manner: assuming that if the following formula were true, it would make economic sense to phase out an existing coal fired power plant:



Some additional values could be added into the formula, to represent the very significant impacts of "externalized" costs and benefits, as describe below; but the basic pattern remains the same:

If the values of the fuel savings, carbon, sulfur, and other market credits plus the values of water rights obtained from transitioning the coal plant exceed the cost of investing in efficiency improvements and renewable sources of energy over time, then it would be profitable to provide the jobs and energy of the coal plant with more cost-effective and benign strategies.

This simple formula could be complicated by adding costs, such as debt service for the existing plant and repositioning of jobs dependent on the coal economy, such as plant operations, mining, and transporting of coal. However, once viable markets for carbon credits emerge, leading to prices greater than $35/ton for carbon, then the value of the credits over time, combined with the stable long-term benefits of efficiency and renewable technologies, plus the increased numbers of jobs and economic multipliers associated with efficiency and renewable sources of energy exceed the value of the coal plant very quickly.

Long-term finance plans can include the costs of retraining and/or relocating displaced workers and providing "green" economic development for coal-based economies such as Appalachia. Colorado, Montana and Wyoming are already shifting from coal to wind. These factors make it profitable to plan to phase out or convert existing coal plants prior to their normal life expectancy.

This analysis does not include operation and maintenance costs (O&M – fixed and variable), capital additions, or pollution control retrofits. Although costs associated with carbon capture and sequestration are shown in the accompanying Dashboard Calculator and cited as one possible condition that might trigger the cost-effectiveness of this analysis, inclusion of these added costs would simply make the present recommendations even more compelling and is not necessary to establish the basic feasibility of phasing out coal plants with efficiency improvements and clean, renewable sources of supply.

It is the intent of this report to provide a general characterization of the major revenue sources and required investments, as “proof of concept.” Since the basic formula is sufficient to establish feasibility, some details have been left out of this “broad brush” analysis. As mentioned previously, the authors propose that if the values of the carbon, sulfur, and other market credits plus the values of water rights obtained from phasing out the coal plant and the saved fuel costs exceed the required investment in efficiency improvements and renewable sources of energy over time, then it will be profitable to phase out the coal plant while providing more benign strategies for creating jobs and meeting energy needs.

The authors propose this analysis as a way to demonstrate “order of magnitude” revenues and investments necessary to establish overall feasibility. More detailed analyses and specific details of financing terms and mechanisms will be required for specific instances, on a plant-by-plant basis.

When implementing these possibilities, it is very important to ensure that local impacts on families and communities who depend on the coal economy be properly mitigated. For example, the numbers of jobs provided by renewable energy technologies and efficiency improvements may be superior to the numbers of jobs in coal mining, transportation, and power plant operation. But if the new jobs are in Phoenix, Los Angeles, or Memphis, and the prior jobs from coal mining, transportation, and coal plant operation were in the Navajo Nation, West Virginia, or Montana, some careful and compassionate planning for retraining and economic development in the affected areas will be required on all sides, in order to provide equitable opportunities for the people whose lives are changed by the transition. This can be done through proper location of industries, such as manufacture of wind turbines or solar panels, as well as innovative economic development, such as sustainable agriculture and forestry projects, watered by sources previously designated for coal plant cooling, slurry lines, etc.

In addition to the economic reasons for shifting the jobs and energy of coal plants to more benign and more profitable strategies, the authors of this report note that many important, technological transitions have not been brought about by economic reasons, but by other reasons, such as, convenience, aesthetics, or style.

When first introduced, electric and propane-powered refrigerators were not cheaper than iceboxes. Nor were electric and gas-fired ranges cheaper than wood cook stoves. They were more healthful and more convenient and therefore worth the investment.

Nor did millions of people adopt iPhones because they were cheaper.

Some technological transitions are simply a matter of choice.

4. Financial Estimates

For this report, Natural Capitalism Solutions analyzed the value created by phasing out an existing coal plant early. As shown in the equation below, the value of phasing out an existing coal plant early was calculated as follows:

- Sale of credits for SO_x, NO_x, and CO_2 plus
- Resale of water rights plus
- Saved fuel costs from not operating the plant.

These values were contrasted with estimates of the investment required to shift the jobs and annual generating capacity of the coal plant, if the savings resulting from phase-out of the existing plant were applied to efficiency improvements and renewable energy technologies.

For each component of the calculation, the authors used low, medium, and high estimates of revenues and investment amounts, to compare various combinations, such as low-low, medium-low, medium-medium, etc. The most cost effective and likely scenario was to compare the medium revenue projections with medium investment requirements, as shown on pages 15 and 16, below.

Although noted as large and potentially significant, avoided costs of carbon storage and/or sequestration are not required to balance the basic equation, nor is it necessary to include possible revenues from sale of renewable energy credits, other than a small premium for selling "green" electricity from renewable sources of supply.

Secondarily, the analysis includes broader economic and social values of local jobs, economic multipliers from those jobs, avoided costs of health care, impacts on property values, and some lifecycle estimates of various other criteria used in impact analysis based on the National Environmental Policy Act (NEPA).

Subsequent sections include financial estimates and broader descriptions of the benefits derived from eliminating the costs associated with coal fired power plants including coal mining, emissions, water, and health impacts, as well as the value added by local jobs in energy efficiency and renewable technologies.

Footnotes documenting sources from which estimates shown in this section were obtained are listed on the accompanying spreadsheet Dashboard Calculator.

Emission Credits, Water Rights, and Fuel Costs

U.S. sulfur (SO_x), nitrogen (NO_x), and carbon markets are still in their infancy. However, as noted above, federal cap and trade legislation,[12] court-mandated EPA regulation of carbon dioxide emissions as harmful pollutants, export requirements imposed by European and other markets, Chinese/Indian leadership in implementing energy efficiency and renewable sources of supply,[13] and various other factors are likely to cause the value of pollution credits to rise significantly, in the very near future. According to the U.S. Energy Information Administration, carbon credits could rise as high as $191/ton by 2030.[14] However, **once the value of carbon credits to rise to $35/ton**, through legislation or market activity, the scenarios described in this report become cost effective. In 2008, the US Environmental Protection Agency estimated impacts of the Lieberman-Warner proposals for cap and trade, using projected costs of carbon ranging between $22 and $200 per ton.[15] A more conservative Congressional Budget Office estimate of the impacts of Waxman-Markey legislation, released in June 2009, uses $28/ton.[16]

Table 3, below shows the range of SO_2, NO_X and CO_2 emission credits prices that were used in this analysis.

These numbers are estimates and therefore subject to debate. Footnotes describing sources of the information contained in the following figures are provided in the Excel Dashboard Calculator workbook, which accompanies this report and are not repeated here, for brevity.

Table 3: Emission Costs

Emission Costs	**Low**	**Medium**	**High**
SO_2 emissions (possible credits) ($/ton)	$65	$550	$1,200
NO_x emissions (possible credits) ($/ton)	$300	$1,500	$3,500
CO_2 emissions (possible credits) ($/ton)	$5	$35	$60
Emissions Produced Annually			
Average SO2 produced (tons/MWh coal)*	0.00069	0.00069	0.00069
Average NOx produced (tons/MWh coal)	0.00025	0.000350	0.00045
Average CO2 produced (tons/MWh coal)	0.80000	0.925000	1.05000

*(note: NGS has low sulfur emissions, due to the installation of wet scrubbers on all three units in 1999[17])

12 For a description of "cap and trade," see http://www.epa.gov/captrade/index.html.
13 http://www.americanprogress.org/issues/2009/06/china_energy_numbers.html.
14 http://www.eia.doe.gov/oiaf/servicerpt/hr2454/execsummary.html.
15 http://www.epa.gov/climatechange/downloads/s2191_EPA_Analysis.pdf, slide 24.
16 http://www.cbo.gov/ftpdocs/103xx/doc10327/06-19-CapAndTradeCosts.pdf
17 http://www.srpnet.com/about/stations/navajo.aspx

The value of water varies widely in the U.S., but is likely to rise dramatically as global warming causes chronic, long-term drought. Particularly in the arid Southwest, water rights are becoming increasingly valuable. However, other regions, including Mid-Atlantic and Southeast states have recently tasted the impacts of drought, and have seen projections of urban and suburban water shortfalls as early as 2025.[18] Water prices in Texas have already risen above $1,000 per acre-foot,[19] and urban and suburban developments will soon compete with agricultural water users for scarce supply elsewhere.[20,21] Table 4, below, shows the revenue resulting from three different values per acre-foot of water used in this analysis ($131, $630, $1,400), to calculate potential levels of revenue that could be obtained if water rights were resold to other users.[22] Navajo Generating Station Is entitled to approximately 34,100 acre-feet of water per year.[23] NGS also emits approximately 0.00069 ton/MWh of SO_2, 0.0019 ton/MWh of NO_X and 1.1 tons/MWh of CO_2.[24] As a sample calculation, Table 4 summarizes the potential future values (low, medium and high) of emission credits from NGS, given the production and emission rates at the costs and credit prices listed in Table 3, on the previous page. Other values can be obtained using the accompanying electronic spreadsheet Dashboard Calculator.

In summary, Table 4 shows the **potential annual revenue** that could be realized by phasing out Navajo Generating Station and selling the water rights and pollutions credits, along with the saved fuel costs a small premium for green electricity (adding $0.01, $0.02, and $0.03/kWh for low, medium, and high to base load, and $0.02, $0.03, and $0.04 to peak load prices).

These costs are estimated annual costs in dollars per year. Although the base years vary slightly, the variance is not considered significant.

Table 4: Revenue Streams

Potential future revenue streams from phasing out existing plant **($/year nominal phase-out year $)**	**Low**	**Medium**	**High**
Annual value of SO_2 credits	$769,011	$6,507,015	$14,197,124
Annual value NO_x credits	$1,277,303	$8,941,118	$26,823,353
Annual value CO_2 credits	$68,122,800	$551,368,913	$1,072,934,100
Annual resale value of water	$3,439,009	$16,538,745	$36,752,767
Annual saved fuel costs	$288,785,833	$449,610,480	$830,246,625
Premium for “green” electricity	$163,494,720	$299,740,320	$435,985,920
Total revenue streams in $/year	$525,888,675	$1,332,706,590	$2,416,939,889

[18] http://74.125.155.132/search?q=cache:WpftS2GBzT0J:www.ppines.com/attachments/7620.pdf+southeast+projected+water+shortfall+by+2025&cd=1&hl=en&ct=clnk&gl=us&client=safari
[19] Seeking Alpha. *T. Boone Pickens Invests in Water - Should You?* 17 January 2007. http://seekingalpha.com/article/24410-t-boone-pickens-invests-in-water-should-you
[20] http://www.kansascityfed.org/publicat/ten/pdf/spring2009/waterrights.pdf
[21] http://www.fao.org/docrep/v7890e/V7890E05.htm
[22] Coal plant statistics taken from values provided by the EIA for existing coal plants in 2005. Spreadsheet summary provided by Roger Clark of Grand Canyon Trust, April 1, 2009.
[23] United Statues Department of the Interior, National Park Service. *Environmental Assessment for the Navajo Generating Station Water Intake Project.* March, 2005
[24] Milford, Jana. *Clearing California’s Coal Shadow from the American West.* Environmental Defense. 2005. Viewed at http://www.cleanpower.org/ceert_reports/Coalreport.pdf 15 July 2009.

Efficiency and Renewable Alternatives

The generation capacity and jobs of Navajo Generating Station could be provided by a combination of efficiency and renewable energy sources. This section of the report summarizes the investments required to implement efficiency and a combination of wind, concentrating solar power-power tower, biomass, solar photovoltaic, and geothermal energy systems, instead of operating Navajo Generating Station. Each of these technologies is discussed in more detail in subsequent sections of this report. The accompanying electronic Dashboard Calculator allows adjustments in the relative percentages of each technology.

Table 5 shows the low, medium and high cost per kWh for installed efficiency, wind, solar, biomass and geothermal. The low scenario is very optimistic, in terms of the prices that can be obtained. The medium scenario is likely, with incentives and credits. The high scenario should be quite easy to attain. Applying these values to a particular coal plant region will require careful verification, using current market conditions.

Table 5: Renewable Energy Costs per kWh

Installed Energy Costs ($/kWh)	Low	Medium	High
Efficiency	$0.01	$0.02	$0.03
Wind	$0.05	$0.08	$0.10
Solar Photovoltaic	$0.05	$0.08	$0.12
Concentrating Solar Power	$0.06	$0.09	$0.13
Biomass	$0.05	$0.09	$0.13
Geothermal	$0.04	$0.05	$0.08

Using the installed energy costs listed above, Table 6, below shows the low, medium and high investment scenarios for providing the average production of NGS in 2005, using efficiency and renewable technologies, in the percentages shown below. These low medium and high costs are estimated based on various years' dollars, between 2005 and 2007.

Table 6: Investments for Efficiency and Renewable Energy

Annual investment to provide annual average production of NGS using efficiency and renewable technologies	%	Low*	Medium	High
Efficiency	20%	$34,061,400	$51,092,100	$102,184,200
Wind	35%	$298,037,250	$476,859,600	$596,074,500
Solar Photovoltaic	5%	$42,576,750	$68,122,800	$102,184,200
Concentrating Solar – Power Tower	30%	$306,552,600	$459,828,900	$664,197,300
Biomass	5%	$42,576,750	$76,638,150	$110,699,550
Geothermal	5%	$34,061,400	$42,576,750	$68,122,800
Total	100%	$757,866,150	$1,175,118,300	$1,643,462,550

*Note: "Low" scenario assumes $.01/kWh for efficiency improvements and other optimistic valuations.

Carbon Capture and Sequestration

As a way to control carbon dioxide emissions that lead to climate change, coal plants may be required to install carbon capture and sequestration equipment in the future. Table 7, below lists low, medium and high cost estimates for implementing carbon capture and sequestration.

Table 7: Carbon Capture and Sequestration Cost per Ton

	Low	Medium	High
Potential cost for carbon capture and sequestration[25] ($/ton CO2)	**$38**	**$64**	**$85**

Based on these unit costs, Table 8 summarizes the potential costs of carbon capture and sequestration for Navajo Generating Station.

Table 8: Carbon Capture and Sequestration Costs for Navajo Generating Station

Carbon capture and sequestration	Low	Medium	High
Annual costs of carbon capture and sequestration	$517,733,280	$1,008,217,440	$1,519,989,975

Because the requirements for carbon sequestration are not certain yet, these numbers have not been included in the calculations on which the recommendations for this report are based. They are included here for reference purposes, since many coal proponents recommend this expensive technology as an appropriate means of mitigating the carbon emissions of coal. The authors of this report respectfully disagree – carbon capture and sequestration will be very expensive.

Analysis

According to the US Energy Information Administration, Navajo Generating Station has 15 more years remaining in its useful service life, which means its scheduled "retirement" would be in 2024. For the purpose of this analysis the authors assumed only that the phase-out of the coal plant would result in carbon and other pollution credits, and did not include any figures for the sale of renewable energy credits, future pollution control upgrades to meet "Best Available Retrofit Technology" (BART), or carbon sequestration. Table 9, below compares approximate, total investments in efficiency and renewable sources of supply, deducted from the value of pollution credits, water, avoided coal costs, and "green" electricity premium prices (from Tables 4 and 6, above):

Table 9: Revenue vs. Investment (from Tables 4 and 6, above)

Annual surplus or deficit ($/year)	Low revenue Low investment	Low revenue Medium investment	Medium revenue Low investment	Medium revenue Medium investment
Total	($231,977,475)	($649,229,625)	$574,840,440	$157,588,290

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[25] http://www.businessweek.com/investing/green_business/archives/2009/02/whats_the_best.html?chan=technology_technology+index+page_top+stories - Emerging Energy Research (EER) says CCS becomes affordable at between $38-$85/ton and McKinsey says between $45-$64/metric ton.

Other Benefits of Switching from Coal to Renewables:

In switching from coal to efficiency and renewables, there are other costs and values and, in some cases, specific revenue streams that should also be considered. These include more jobs, increased revenue from electricity sales via green power premiums, and reduced fuel price volatility. There are also substantial savings in health care costs to individuals, insurance companies and the government, associated with reduction or elimination of coal plant emissions as well as reduced missed work days and fewer premature deaths.

In addition to these, the following costs, values and risk considerations should be weighed, when deciding whether or not to phase out an existing coal plant and provide the same jobs and energy services with efficiency and renewable technologies:

- Perhaps the largest untapped benefits of switching from coal to renewable technologies and efficiency are those associated with reduced health care costs and premature death. These are discussed in more detail in subsequent sections of this report.
- Reduced risks associated with fuel price volatility: Coal is a finite resource, subject to changes in price based on availability and demand. These issues are low or non-existent with efficiency and renewables. It is true however that emission markets are also subject to price volatility, but once a credit is sold at a given price, that price should not change based on future market fluctuations. The proposed Waxman-Markey legislation, released in June 2009 includes a consideration for a minimum floor price for CO_2 credits.
- Reduced risk connected with potentially more stringent future regulations and fines associated with mercury, particulates, carbon monoxide (CO) and other pollutants emitted as part of the coal mining and burning process. Mercury emitted from coal plants leads to mercury being deposited out of the atmosphere in ways that can impact concentrations of mercury in soil and water.
- Potential for income associated with emerging ecosystem services markets such as those being developed in the Northwestern United States by the Willamette Partnership and "payment for ecosystem services" (PES) schemes such as those described by the Katoomba Group.[26] Negative effects of mining and burning coal on surrounding ecosystems cannot be denied. Likewise, the benefits of avoiding these negative effects on people and ecosystems are both obvious and well-documented elsewhere in this report. In the not too distant future, it is likely that protecting ecosystems and the services they provide can be a source of revenue through markets and strategies like the "payment for ecosystem services" (PES) system described above.

As noted previously, an accompanying electronic Dashboard Calculator, with adjustable inputs for different mixes by technology type, accompanies this report, which can be used to generate various comparative scenarios.

[26] The Katoomba Group, *Payments for Ecosystem Services, Getting Started: A Primer,* Forest Trends, 2008.

Bridge Financing

The cash flow provided by carbon, nitrogen and sulfur credits, as well as reduced fuel costs and the resale of water rights will continue for the projected life of the coal plant, even after the jobs and services previously provided by the coal plant are converted to efficiency and renewable sources of energy. This long-term cash flow will often be in the hundreds of millions of dollars per year, depending on the size and circumstances of the individual coal plant.

Given this long-term cash flow, it may be possible to assemble financing packages that provide investment dollars for efficiency and renewable sources, as well as repayment of the debt obligations of the coal plant, over a reasonable period of time.

Typically, costs will be on the "front end," whereas benefits will be on the "tail." Thus, high investment in renewable technologies required at the outset, can be repaid by continuing revenues later on, if the length of investment strategies is adjusted appropriately – high up front costs being recouped through subsequent, ongoing revenues from continuing savings.

New models are emerging, to provide financing for these kinds of transitions on local, regional, and state levels, such as those being used in Boulder[27] and San Francisco[28] that provide short-term investment, followed by extended repayment using special districts, municipal bonding, and repayment plans attached to individual properties, rather than ratepayers. The City of Babylon, on Long Island, in New York, has declared carbon a solid waste and is using their solid waste district to finance building improvements.[29]

With proper support from local, regional, state and/or federal governments, other third-party financing options, such as "**power purchase agreements**" may be viable as well. Under power purchase agreements (or similar performance-based arrangements referred to as "Pay As You Save" or "**PAYS**"), one or more third parties provide financing and installation costs for efficiency improvements and renewable energy sources, either on-site or off-site; and the consumers of the energy are charged a nominal rate over time, combining operating costs with energy savings, to result in a monthly or annual payment less than what was previous paid for coal fired electricity.

Similarly, some of this long-term cash flow could be used to provide financing for retraining and/or relocation assistance for displaced workers, whose prior livelihoods depended on coal mines, coal transportation, and/or coal burning power plants, as well as economic redevelopment for communities similarly dependent on the coal economy in regions like the Four Corners area of the Southwest, Appalachia, Pennsylvania, Ohio, Wyoming, and Montana.

The important aspect of bridge financing is that innovative thinking is required to cover all costs, including displaced workers and communities in transition. For example, in order to provide water to the desert, the Central Arizona Project was financed over 50 years, with federal assistance. Similar strategies may be required to finance the transition from coal to more benign and less costly energy sources.

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27 http://www.bouldercounty.org/bocc/cslp/cslpintro.html
28 http://sfwater.org/Files/FactSheets/solarflyer_revAPR09.pdf
29 http://www.thebabylonproject.org/blog/2009/6/22/carbon-in-waste-declared-solid-waste.html

Similar Cost Benefit Analysis: Phasing Out Ontario's Coal-Fired Electricity Generation

In the 2003 Ontario provincial elections, the Liberal Party of Canada claimed a decisive victory by way of its sweeping public policy campaign, pledging, among other things, to phase out all coal-fired power plants by 2007.[30]

This promise to end Ontario's coal fired electricity industry was followed by a September 2009 announcement of formal plans to phase out all the province's 15 coal plants – 4 by 2010, and the other 11 by 2014. When the Lakeview Generating Station stopped operating in April 2005, the plant's 2,400 MW were transitioned seamlessly to more than 7,000 MW of new and refurbished generation brought on-line since 2003, including 3,700 MW from new natural gas plants and more than 1,200 MW from renewable energy sources. With these bold actions, Ontario is poised to reduce its coal capacity by 40 percent compared to 2003 levels, and puts the province on-track to become one of the first jurisdictions in the world to completely phase-out coal.[31]

The release of an April 2005 report titled, *Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation*, provided support for the Province's fiscal-analysis of dirty fuels and documented the health impacts of coal plants.

The report confirmed a strong business case for decommissioning coal plants, drawing on an analysis of four electricity generation scenarios: 1) Base-Case (business as usual), 2) All Gas (produce all of the electricity through gas generation facilities constructed for this purpose alone), 3) Nuclear/Gas (produce all of the electricity through a combination of refurbished nuclear and new gas generating facilities constructed for this purpose alone),
4) Stringent Controls (continue operating the coal plants but install new emission-control technologies).[32]

The Ontario report used an innovative methodological approach to calculate the total and true costs of electricity generation ($/MWh): each of the four scenarios profiled goes well beyond a typical cost-benefit analysis and includes quantifiable costs associated with the health and environmental impacts (see "levelised costs" in the table on the next page).

If only the financial costs were considered and the external costs ignored, the Base-Case scenario appears relatively cost-competitive with any proposed alternative. But when the external health and environmental costs are built in, the business-as-usual scenario appears to be less viable.

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[30] Gipe, Paul. "Coal's High Enviornmental & Social Costs in Ontario." July 5, 2005. http://www.wind-works.org/articles/OntarioCostofCoalStudyReview.html

[31] http://www.news.ontario.ca/mei/en/2009/09/ontario-coal-closure-launches-countdown-to-green-energy.html

[32] *Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation*. April 2005. http://www.hme.ca/reports/Cost_Benefit_Analysis_--_Replacing_Ontario%27s_Coal-Fired_Electricity_Generation.pdf

Table 10: Ontario Comparison: ***Total Cost of Generation***

	SCENARIO			
	1 Base Case	2 All Gas	3 Nuclear/ Gas	4 Stringent Controls
Total Present Value (2007-2026) ($Billions)	$49 ($21)[a]	$29 ($26)	$22 ($18)	$32 ($21)
Annualised Costs ($Millions)	$4,377 ($1,836)	$2,605 ($2,279)	$1,942 ($1,635)	$2,802 ($1,895)
Levelised Costs ($/MWh)	$164 ($69)	$98 ($86)	$72 ($61)	$105 ($71)
Health and Environmental Proportion	77% (46%)	20% (9%)	21% (6%)	51% (28%)

A major point of contention in the Ontario report is the conclusion that a mix of new gas-fired plants and refurbished nuclear plants would be the most viable and cost-effective method for providing the lost generating-capacity of the decommissioned coal plants. Despite compelling data expounding the human/health appeals of switching to a nuclear/gas approach (table below), critics have been quick to highlight a range of analytical shortcomings, and have aptly challenged the markedly low cost-assumptions of nuclear refurbishment. To date, critics have failed to note the significant greenhouse gas contributions and security issues of the full nuclear fuel cycle.

Critics of the report have also pointed out that no mention or consideration was given to a non-fossil fuels approach to reducing electricity demand, a path defined by the aggressive implementation of conservation and efficiency measures.[33] Subsequent work has emphasized biomass as an alternative to coal.[34]

Table 11: Ontario Comparison: ***Summary of Annual Health Damages***

	SCENARIO			
	1 Base Case	2 All Gas	3 Nuclear/ Gas	4 Stringent Controls
Premature Deaths (Total)	668	11	5	183
Premature Deaths (Acute)	103	2	1	28
Hospital Admissions	928	24	12	263
Emergency Room Visits	1,100	28	15	312
Minor Illnesses	333,660	5,410	2,460	91,360

[33] *Report Advocates Nuclear Mistake.* Sierra Club of Canada. Ontario Chapter News Release. http://www.sierraclub.ca/national/media/item.shtml?x=828, viewed September 7, 2009.
[34] http://www.mei.gov.on.ca/english/energy/gea/;
see also http://www.news.ontario.ca/mei/en/2009/09/ontario-power-generations-opg-biomass-energy-program.html

Cost of Carbon

Most utilities and other planners now accept carbon charges as inevitable, whether through "cap and trade," carbon taxes, or capture and storage/sequestration. This report assumes that the cost of carbon will rise and predicts various scenarios in the range of $5 to $35 to $60/ton. A recent report by Public Service Company, a subsidiary of Xcel Energy, one of the United States' largest owners and purchasers of coal-fired electricity, assumed the following future costs for carbon[35]:

CO2 price sensitivities from Xcel Energy:
$10/ton starting in 2010 and escalating at 7% per year
$40/ton starting in 2010 and escalating at 7% per year

Unlike the report above, this report is slightly more conservative than the large utilities, assuming the cost of carbon would only have to be $35/ton, to make the proposed scenario cost effective.

Water

Coal plants use large amounts of water -- for cooling, for slurry lines, and in the future, possibly for treating carbon emissions. For the purposes of this report, the authors have used low, medium, and high estimates of the value of water: $131, $630, and $1,400/acre-foot, respectively. As noted above, in the introduction to this section, particularly in the arid Southwest and Texas, water is becoming increasingly valuable, due to climate change. So the authors of this report consider the prices used for water to be conservative estimates that are likely to rise, as the demands of agriculture, industrial, commercial, residential, and urban development increase pressures on limited water supplies.

[35] Public Service 2009 All-Source Solicitation 120-Day Report 07A-447E_08-10-09, p. 77.

Efficiency Improvements

Q: **How much does it cost to increase the available supply of electricity through efficiency improvements?**
A: **$0.01 to $0.03 per kWh.**

Factoid: **The Los Angeles Department of Water and Power's share of Navajo Generating Station is 477MW. Operating all year, at 90% capacity, this would provide 3,763 MWh of electricity per year.**

Two utilities in the Navajo Generating Station service area have been engaged in "demand side management" energy efficiency campaigns and have obtained significant energy savings for less than $0.03 per kWh saved.

Through its energy efficiency programs, the Los Angeles Department of Water and Power has saved 3,066 GWh of electricity, by investing $0.024 per kWh saved.[36] And, by 2007, Arizona Public Service Company (APS) had saved 3,276 GWh with an investment of $0.011 per kWh saved.[37] By contrast, APS' share of Navajo Generating Station is only capable of sending them 2,485 MWh per year, at a cost of $0.057/kWh, depending on the price of coal and other expenses.[38] Which is the more cost-effective investment?

Other utilities nationwide have shown similar costs either in feasibility studies or in actual results. For example, with their energy efficiency program, between October 2007 and December 2008, Public Service Company of New Mexico achieved lifetime energy savings of about 302 GWh for $0.013 per kWh.[39] Massachusetts' ENERGY STAR lighting program achieved lifetime savings of $0.011/kWh in 2005.[40] The North Carolina Utilities Commission estimates $0.029 per kWh saved as an average cost across all sectors.[41] Sacramento Municipal Utility District found that customers reduced their use by 2% merely when they were provided with information on how their energy use compared to their neighbors and the utility's most efficient customers — 2% savings for nearly zero cost.[42]

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[36] Budget, Rates and Efficiency Division. *LADWP Energy Efficiency Programs, A Presentation to the California Energy Commission.* 9 June 2009. The California Energy Commission. 13 July 2009

[37] " APS Energy Efficiency Program Update. *Resource Alternative Stakeholder Meeting.* 6 June 2008. Arizona Public Service. 13 July 2009 <http://www.aps.com/_files/various/ResourceAlt/Wontor_EE_Program_Update_Final_06042008.pdf>.

[38] Budget Rates and Efficiency Division, 2009,.op. cit.

[39] 2008 Electric Energy Efficiency Program Annual Report. Rep. 1 Apr. 2009. Public Service Company of New Mexico. 14 July 2009 <http://www.swenergy.org/news/2009-04-PNM_2008_Electric_DSM_Annual_Report.pdf>.

[40] Nexus Market Research, Inc., RLW Analytics, Inc., Shel Feldman Management Consulting, and Dorothy Conant. Market Progress and Evaluation Report Evaluation Report (MPER) For the 2005 Massachusetts ENERGY STAR Lighting Program. Rep. 29 Sept. 2006. Cape Light Compact, Massachusetts Electric Company, Nantucket Electric Company, NSTAR Electric, Western Massachusetts Electric Company, Unitil. 8 July 2009 http://www.cee1.org/eval/db_pdf/474.pdf

[41] GDS Associates, Inc. A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina. Rep. Dec. 2006. North Carolina Utilities Commission. 9 July 2009 <http://www.ncuc.commerce.state.nc.us/reps/NCRPSEnergyEfficiencyReport12-06.pdf>.

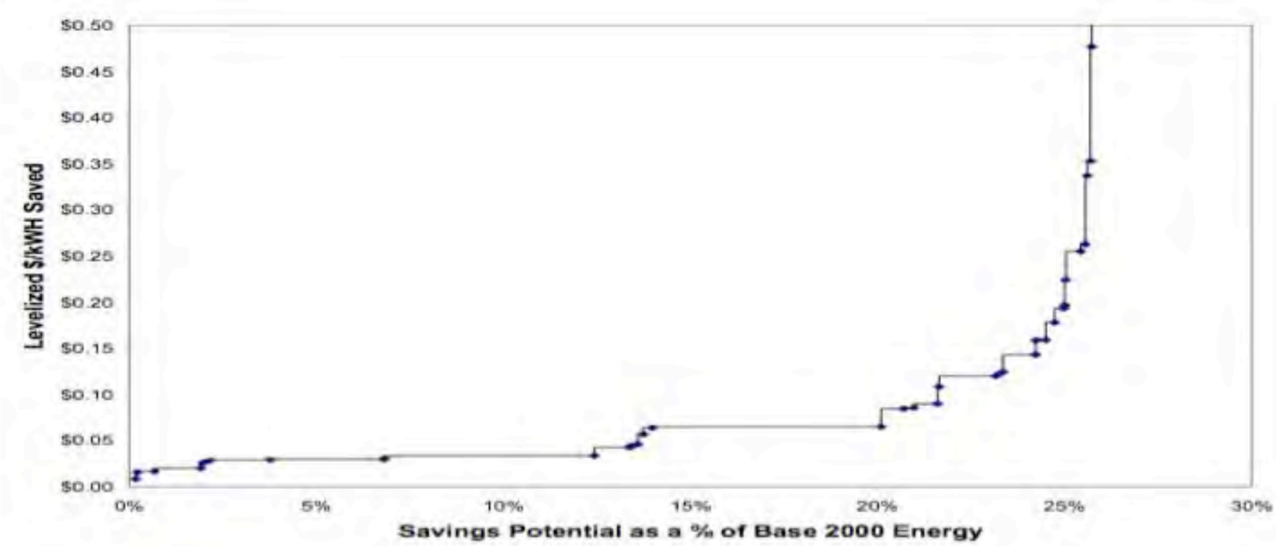
[42] Sanserino, Michael, *Peer Pressure and Other Pitches,* Wall Street Journal, September 14, 2009.

Q: **How much potential is there for energy efficiency improvements?**

A: **In most regions, more than is required to eliminate one or more coal plants.**

The potential for energy efficiency is largely tied to budget and the cost per kWh that a sponsor is willing to pay. Although there are some practical limits to how many Compact Fluorescent Lights and how many movement sensors and automatic light switches a sponsor can install, most utilities are nowhere near those limits in their service territories. There has not yet been a truly effective social mobilization campaign to achieve saturation of the potential for energy efficiency, comparable to what some communities have achieved with recycling. Current projections assume that increasing the efficiency with which end users meet their needs will become incrementally more expensive. But there is no example of a community that has tested economies of scale, such as bulk purchasing or subsidized green jobs creation for programs like "Two Techs and A Truck" which has been proposed for Boulder, CO.[43] Conventional projections always include an assumption that as the cheapest energy efficiency measures become saturated, the remaining energy savings begin to cost more, as illustrated by this California residential electric energy efficiency cost curve.[44]

Table 12: Residential Electric Energy-Efficiency Supply Curve



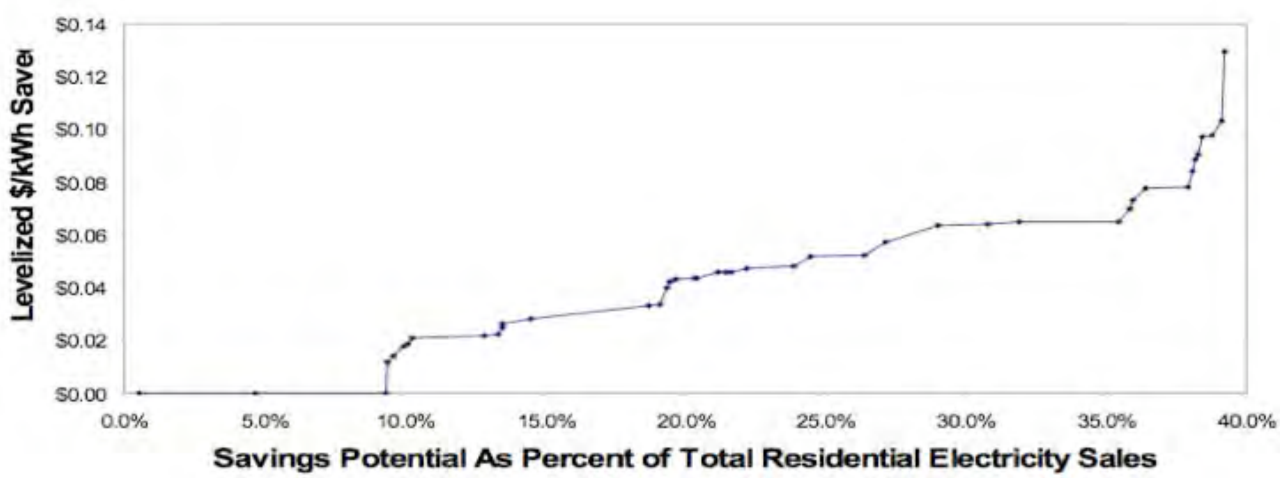
However, in 2007, the LADWP residential total energy use was 8,426 GWh.[45] A truly effective energy efficiency campaign resulting in saving 10% of that electricity might require an investment as low as $0.01 to 0.03/kWh and would yield annual savings of 842.6 GWh. Nevada Power Company estimates that there is potential to save 3,093 GWh of electricity (14.3% off the baseline

[43] http://www.examiner.com/x-11366-Boulder-Page-One-Examiner~y2009m6d12-Boulders-two-techs-and-a-truck-climate-action-plan
[44] Coito, Fred, and Mike Rufo. CALIFORNIA STATEWIDE RESIDENTIAL SECTOR ENERGY EFFICIENCY POTENTIAL STUDY, Volume 1 of 2. Rep. no. SW063. Apr. 2003. 8 July 2009 <http://www.calmac.org/publications/Res_EE_Potential_Study_V1.pdf>.
[45] "Energy Consumption by Planning Area." Energy Consumption Data MAnagement System. CA.gov. 15 July 2009 http://ecdms.energy.ca.gov/elecbyplan.asp

projection) by 2030. These represent gains beyond codes and standards over this time period.[46] Adding effective codes and standards (such as are found in Osage, Iowa, where customers are required to meet energy efficiency standards in the same way restaurants are required to meet health codes[47]) could add at least 1% to the annual potential for energy savings (as an aside, every $1.00 spent on energy efficiency in Osage has been shown to create $1.90 in economic benefit[48]). In another example, in 2007, Vermont published the results of a comprehensive study on their energy efficiency potential and concluded that across all sectors (residential, commercial and industrial) they had an achievable, cost effective potential to save a cumulative total of 1,286 GWh, or 19.4% of their project energy sales by 2015.[49]

The Vermont Residential Electric Energy Efficiency supply curve is shown below:

Table 13: Residential Electric Energy-Efficiency Supply Curve for Vermont



Based on the above examples, this report assumes that greater energy efficiency is possible, and that larger investments will reap larger savings. "Power purchase agreements," and performance-based, "pay as you save" programs, where the end user shares savings with those who finance and install energy efficiency measures, can help to keep these costs low, as can larger investments in community-based infrastructure, such as those offered in Boulder,[50] San Francisco,[51] and other cities, as mentioned above.

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[46] *Nevada Power Company Integrated Resource Plan 2010 - 2029: Demand Side Plan 2010 - 2012.* Issue brief. Nevada Power Company d/b/a NV Energy. http://www.swenergy.org/news/2009-07-NV_Power_DSM_Plan_01.pdf
[47] http://www.energy.iowa.gov/OEI/docs/Legislators.pdf
[48] ibid.
[49] GDS Associates, Inc. Vermont Electric Energy Efficiency Potential Study, Final Report. Rep. Jan. 2007. Vermont Department of Public Service. <http://publicservice.vermont.gov/energy/vteefinalreportjan07v3andappendices.pdf>
[50] http://www.bouldercounty.org/bocc/cslp/cslpintro.html
[51] http://sfwater.org/Files/FactSheets/solarflyer_revAPR09.pdf

Renewable Energy Options

For most coal plants, some or all of the electricity generated is used for relatively constant, base load services. For example, in the case of Navajo Generating Station, as noted in Section 2 (page 3, above), some of the electricity provided by NGS is used for pumping water for the Central Arizona Project. If service territories begin by investing in more efficient ways to meet end-use needs, electricity demands can be reduced, but probably not entirely eliminated. While sensible architecture can eliminate most of the demand for electricity for heating and cooling, some appropriate uses, such as pumping water, lighting, electronics, and industrial shaft power will remain. Thus, before coal fired plants can be taken offline entirely, alternative sources of energy must be provided, to cover base load and peak load needs.

Wind

Electricity from wind can cost as little as $0.05/kWh.[52] With regional investments in transmission capacity, this cost could continue to drop. Although wind and solar are often dismissed as unreliable, analysis by the Rocky Mountain Institute has shown that a "portfolio" approach to wind resources produces much greater reliability. Large, diverse, portfolios of providers can greatly increase the reliability at predictable levels of both wind and solar portfolios.[53]

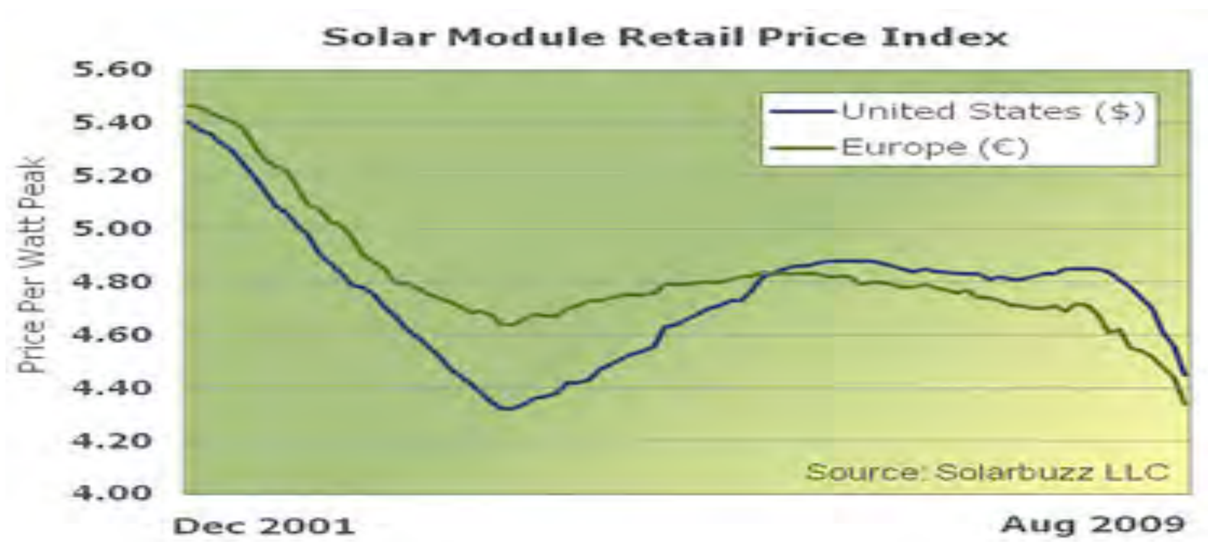
[52] http://www.awea.org/faq/wwt_costs.html
[53] http://www.rmi.org/images/PDFs/Palmintier_SolarandWindinNGU(SOLAR2008).pdf

Solar Photovoltaic

The cost of solar photovoltaic (PV) is trending downward and is expected to reach prices competitive with those currently charged for electricity from fossil fuels by 2015. Developments in solar technologies, dropping prices of certain materials, and government incentives all have a powerful impact on the price of solar photovoltaic installations. It is currently possible to generate solar PV electricity at $0.036 per kWh in New Jersey, a state with effective rebates and incentives (the cost would be $0.23 without incentives).[54] In Pennsylvania a 130 kW PV system can generate electricity for $0.045 after incentives.[55] In Colorado, delivered prices for electricity from solar photovoltaic panels of $0.05/kWh or less have been quoted when aggressive installation and cost control are combined with incentives.[56]

Additionally, advances in PV technology lead experts to expect to see prices drop to $0.146 per kWh (without incentives) by 2012,[57] and the field of concentrating solar PV, with its ever increasing efficiencies (now up to 37.5%) are currently pushing PV electricity costs down to $0.05 per kWh (without incentives).[58]

Table 14: Solar Module Retail Price Index



[54] http://www.siliconsolar.com/new-jersey-grid-tie-solar-electric.html. This New Jersey solar developer details the costs and incentives of installing a 1.3 kw residential system. The total cost is $9,147 minus a $4,940 rebate and a $2,744 tax credit which yields a balance of $1,463. The lifetime (assumed to be 25 years) AC output is 40,650 kWh. $1,463 / 40,650 kWh = $0.036 / kWh. Without the government incentives the system would generate electricity at $0.23 / kWh.
[55] *Economic Viability of Solar Power in Pennsylvania*. Rep. EOS Energy Solutions, Feb. 2009. Web. 19 Aug. 2009. http://www.eosss.com/pdfs/SolarWhitePaper_PA.pdf. The table on page 9 outlines the costs and rebates of a 130 kW commercial system. It estimates the system will generate 20% of the buildings 750,000 kWh per year electricity consumption (150,000 kWh per year or 3,750,000 kWh over 25 years). The cost of the system is estimated at $1,000,000 before government incentives and at $170,000 after them. This yields $0.045 per kWh over the life of the system.
[56] email communication from Simple Solar Electric Systems, Boulder, CO,
[57] http://www.solarfeeds.com/alt-dot-energy/5981-china-plans-to-cut-cost-of-solar-power-to-0146-per-kwh-in-2012.html
[58] http://www.sunrgi.com/press20080429.html

Covering the Central Arizona Project with Photovoltaic Solar Panels

Effective implementation of solar PV will require innovative, bold thinking. One such proposal is to cover the Central Arizona Project (CAP) with photovoltaic solar panels.

The 336-mile long CAP aqueduct carries water from the Colorado River to Phoenix and Tucson, and is the largest single renewable water supply in the state of Arizona. It was a visionary project, brought on by “out of the box” thinking. It required major federal funding, and a fifty-year payback plan, but the CAP has made possible a different way of life in the desert. Similarly audacious, visionary thinking will be required to get beyond the pollution, illness, lifestyle, and other costs of burning coal.

The CAP’s corridor and transmission system are federally owned assets that could be used to generate and distribute as much as 2,602 GWh of solar electricity per year, while saving large amounts of marketable water from evaporation. Solar PV panels could be used innovatively, as a shading solution over the canal. If the price of “green” electricity sold during peak periods rises above $0.17 per kWh, then it may become cost effective to cover the CAP with solar PV panels, with a payback period as brief as 16 years, depending also on the price of saved water.

The aqueduct travels through prime solar-generating country but is also prone to large evaporative losses: 5% of its water is lost (75,000 acre-feet per year). Covering the considerable surface area of the aqueduct with photovoltaic solar panels would reduce evaporation and yield a double benefit of generating 2,602 GWh of electricity each year.

Sales of the electricity and increased water could be used to improve the repayment of principal and provide return on investment in this considerable project in less than 20 years, without any rebates or incentives. The economic attractiveness of a proposal to place photovoltaic solar panels on the canal could be improved, but even in the simple calculations, covering the canal with electrical generation capacity is an example of the kind of audacious thinking that might open new horizons in similar ways to the “bloom in the desert” represented by the original canal project. The numbers presented below will also become more attractive as government incentives are factored in and the price per watt of solar panels continues to fall.

Table 15 (next page) outlines two combinations of three primary scenarios: Scenario A plus B -- covering the CAP with solar panels on a simple structure that would shade the water; or Scenario A plus C -- covering the CAP with a watertight structure on top of which the panels would sit. The scenarios are broken down into their component parts to analyze the costs. Thus, the costs of the solar panels themselves must be paired with either the simple frame spanning the canal described in Scenario B or the watertight structure described in Scenario C. At present, it appears that the first combination – placing panels atop an open structure spanning and shading the canal, but not water tight, would be the most cost-effective option. It is assumed that nearly 30% of the distance would not be covered, due to existing tunnels, pumping facilities, and curves, as shown on the next page.

Table 15: Covering the Central Arizona Project with Photovoltaic Panels

Covering the Central Arizona Project with PV solar panels					
	Scenario A: Just Solar Panels (must be mounted on scenario B or C).	**Scenario B:** Simple frame for solar panels over the canal.	**Scenario C**: Watertight structure over the canal.	**Scenario A + B**	**Scenario A + C**
Aqueduct Length (ft)	1,774,080	1,774,080	1,774,080	1,774,080	1,774,080
Cost (in millions)	$7,950.7[59]	$443.5-$887[60]	$443.5-$2,661[61]	**$8,394 –$8,838**	**$8,394 –$10,612**
Water savings per year (acre-ft)	NA	NA	75,000[62]	**37,500**[63]	**75,000**
Value of savings at $1000 / acre-ft ($/yr)	NA	NA	$75,000,000	**$37,500,000**	**$75,000,000**
Suitable solar area (sq ft)	134,120,448[64]	NA	NA	134,120,448	134,120,448
Electricity generated (Gwh/yr)	2,602[65]	NA	NA	**2,602**	**2,602**
Value of generated electricity ($/yr) at 2007 average retail price of Arizona electricity **8.54 cents per kWh** (EIA) **and at a peak, green electricity rate estimate**: **17 cents per kWh**	$222,245,711 or $442,409,495	NA	NA	$222,245,711 or $442,409,495	$222,245,711 or $442,409,495
Value of generated electricity at both prices plus water savings ($/yr)	$222,245,711 or $442,409,495	NA	75,000	$259,745,711 or $479,909,495	$297,245,711 or $517,409,495
Payback period with electricity and water sales: at **8.54 cents/kWh**	36 years	NA	6 – 35 years (no solar)	**32 – 34 years**	**28 – 36 years**
Payback period with electricity and water sales: **17 cents/kWh**	18 years	NA	NA	**17 – 18 years**	**16 – 21 years**
Sources: Jonathan Rademaekers, Natural Capitalism Solutions. Telephone interview with Bob Barrett, Central Arizona Project. July 20, 2009 Jonathan Rademaekers, Natural Capitalism Solutions. Telephone interview with Tim Bugh, Standard Renewable Energy, Phoenix. July 22. 2009.					

[59] Determined by using the price of $4.94 per watt quoted by Standard Renewable Energy x 180 watts for the proposed solar panels = $889.2 per panel. Each panel is 15 square feet = $59.28 per square foot. This was then multiplied by the suitable solar area of 134,120,448 square feet.

[60] Quotes varied from $250-$500 per linear foot of structure. This structure spans the aqueduct and can support the solar panels which will provide shade but is not water tight.

[61] Quotes varied from $250-$1500 per linear foot of structure. This structure would span the aqueduct and provide support for the solar panels while also providing a watertight covering. Any watertight covering of the CAP would have to allow for maintenance, therefore some of the higher end quotes allow for modular or removable sections as well as windows and doors that allow access to under the cover.

[62] The CAP loses approximately 5% of its water due to evaporation. That equates to 75,000 acre-feet per year. It is assumed that the watertight covering would prevent all this loss.

[63] Shade cloths have been shown to reduce evaporation between by 40-80%. This structure would use the solar panels as the shading medium and the assumed reduction in evaporation would be 30-80%, we use 50% for this analysis. The CAP loses about 75,000 acre-feet of water per year due to evaporation.

[64] Useable area for solar panels was determined by assuming 120 ft useable width of structure over the 1,774,080 foot long aqueduct (336 miles x 5280 ft). This area is 212,889,600 square feet. It is then assumed that 30% of the aqueduct will not be suitable for panels tilted toward the sun due to aqueduct curves, tunnels, pipes and other factors. Another 10% is removed to allow for tilted panel spacing. This yields 134,120,448 square feet of solar panels.

Concentrating Solar

Like most energy sources, initial investment is required for new concentrating solar power (CSP) plants, whether parabolic trough or power tower. Over the entire lifecycle of the plant, 80% of the cost is from construction, and only 20% is from operation. After about 25 or 30 years, once the construction costs for the plant have been paid; the operating costs remain about $0.03/kWh. After this time, the CSP plant's electricity is cheaper than any competition; comparable only to "long-written-off" hydropower plants.[66]

> *"NREL, working through SunLab, supports the U.S. Department of Energy's goal to install 1,000 megawatts (MW) of new concentrating solar power systems in the southwestern United States by 2010. This level of deployment, combined with research and development to reduce technology component costs, could help reduce concentrating solar power electricity costs to $0.07/kilowatt-hour. At this cost, concentrating solar power can compete effectively in the Southwest's energy markets."*[67]

Another NREL report documents costs for electricity from concentrating solar-power tower plants as low as $0.11/kWh, and for parabolic troughs as low as $0.10, in 2004, but dropping to $0.055 and $0.062 respectively by 2020, which, when combined with heat storage to produce reliability, will make concentrating solar electricity a very affordable alternative to coal.[68]

Though not sufficiently cost effective to warrant inclusion in the calculations for this report yet, Stirling Energy Systems and Tessera Solar have recently announced installations of the most efficient solar systems in the world, using concentrating parabolic mirrors to focus sunlight on a mechanical generator that requires no water to produce 25kW of electricity at prices as low as $0.15/kWh.[69]

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[65] This is based on an annual average solar radiation of 6.57 kWh/m^2/day, which yields 161,696 kWh of AC energy per year per 100 kW of solar panel when panels are placed at an optimum angle. Our system is based on 12 watts / sq ft (180 watt solar panels are 15 sq ft in size). This yields system rated at a total of 1,532.8 MW.

[66] "Concentrating Solar Power Global Outlook 09: Why Renewable Energy is Hot." *Greenpeace International*. 2009. http://www.greenpeace.org/raw/content/international/press/reports/concentrating-solar-power-2009.pdf

[67] "Solar Module Price Highlights: July 2009." *Solarbuzz*. August 2009. http://www.solarbuzz.com/Moduleprices.htm

[68] Sargent & Lundy LLC Consulting Group, October, 2003, *Assessment of Parabolic Trough and Power Tower Solar Technology Coast and Performance Forecasts.* NREL, Golden, CO.

[69] http://www.lincolncountyrecord.com/pages/EventsCalendar/mo/8/yr/pages/pages/090806blt

Biomass for Power Generation and Combined Heat and Power

Biomass is not appropriate in some areas. For example, on the Navajo Nation, the heritage forests are a precious aspect of cultural heritage, which many residents consider sacred. In other regions, where the use of regional resources for biomass feed stocks causes negative impacts on natural and cultural resources and heritage, or where the combined firing of a power plant with both biomass and coal would perpetuate the negative impacts of coal, it may also be more effective to choose other options. However, in regions where biomass feed stocks can be obtained cost effectively from such sources as agricultural processes, urban greenwaste, or appropriate non-food crops, biomass may provide cost-effective alternatives to coal as a fuel source.

If it is used for co-firing with coal, biomass complicates the analysis, because coal plants would not be fully phased out – they would still continue to burn coal much of the time. Co-firing with coal/biomass also would reduce the CO_2, SO_2, and NO_x credits as compared with solar or wind, because the plant would still be producing electricity by burning solid fuels and thus generating CO_2, SO_2, NO_x, etc. Nonetheless, it is included here as a matter of thoroughness, because some producers are generating electricity in stand-alone biomass plants, because Ontario, Canada considers it a viable alternative to coal,[70] and also because some producers have proposed innovative scenarios to site local biomass facilities near agricultural waste sources along existing transmission lines.[71]

Co-firing using biomass such as wood pellets in coal power plants requires limited incremental investment ($50-$250/kW) and the electricity cost may be competitive ($0.02/kWh), if the biomass is available at a low cost with a limited need for transportation. When the biomass costs $3-$3.5/GJ, the electricity cost may be only $0.03-$0.05/kWh. One small biomass producer in Colorado can provide electricity from biomass at $0.067/kWh, including construction costs.[72] Table 16, below lists the capital costs for various biomass projects and the cost/kWh for each.

Table 16: Typical Data and Figures for Power Generation from Biomass[73]

Technologies	**Efficiency**	**Typical size**	**Typical -**	**Costs**
	% (LHV)	MWe	**Capital**, $/kW	**Electricity**, $/kWh
Co-firing	35-40	10-50	1100-1300	0.05
Dedicated steam cycles	30-35	5-25	3000-5000	0.11
IGCC	30-40	10-30	2500-5500	0.11-0.13
Gasific.+ engine CHP	25-30	0.2-1	3000-4000	0.11
Stirling engine CHP	11-20	<0.1	5000-7000	0.13

70 http://www.news.ontario.ca/mei/en/2009/09/ontario-power-generations-opg-biomass-energy-program.html
71 www.sanjuanbioenergy.com. Email communication with Paul Sheldon, Natural Capitalism Solutions, 8/11/09.
72 Ibid.
73 *Biomass for Power Generation and CHP.* i *IEA Energy Technology Essentials.* January 2007. http://www.iea.org/Textbase/techno/essentials3.pdf; *Energy Technology Perspectives* (IEA, 2006); *World Energy Outlook* (IEA, 2006); REN21 – Global Status Report. 2005 and Update 2006 (www.ren21.net; www.iea.org; www.ieabioenergy.com; International Bio-Energy Partnership (www.fao.org). **Data Confidence –** Power generation from biomass includes a number of processes and feedstocks. Data refer to typical technologies but wide ranges exist, depending on process, feedstock, transport and local conditions.

Geothermal

Geothermal electricity and ground source heat pumps often are cost-competitive in areas where solar and wind are not. Particularly at the scale of a neighborhood or an institution, where communities or private sources provide long-term financing, geothermal systems provide efficient, affordable, year-round substitutions for electricity-powered heating, ventilation, and air conditioning systems.

Cities in California, such as Riverside, are obtaining electricity from geothermal sources in the range of \$0.07 - \$0.08/kWh by entering into carefully negotiated power purchase agreements.[74]

[74] Power Purchase Agreements between City of Riverside and Shoeshone Renaissance, LLC, June 19, and December 12, 2008.

Emissions

The Dashboard Calculator, which accompanies this report, allows inputs for the various pollutant emissions specific to the coal plant under consideration. For the analysis contained in this report, the following emissions amounts were used as the test case, based on the 2005 operations of Navajo Generating Station[75]:

Table 17: Navajo Generating Station Emissions

Pollutant	Emissions
CO_2	690,527 tons
SO_2	1,281 tons
NO_x	11,581 tons
Mercury	91 pounds

Electric utilities produce 66% of all sulfur dioxide emissions nationwide. The 50 dirtiest power plants are responsible for 78% of all the sulfur dioxide produced by the electric power industry. Power plants are also the source of 29% of nitrogen oxide (NO_x) emissions. 65% of electric utility plants were built before enactment of the Clean Air Act Amendments of 1977. Some of the old, "grandfathered" power plants emit harmful pollutants at four to ten times the rate allowable for new plants built today.[76]

75 http://www.sourcewatch.org/index.php?title=Navajo_Generating_Station#Emissions_Data
76 http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=23353#power

Jobs

How many jobs can energy efficiency programs create?
There is a net increase in jobs when energy efficiency is used to decrease energy use.

> **"The positive employment and income results are due primarily to the relatively low labor intensity of the energy sectors (coal, oil and gas extraction, fuel refining, and electric and gas utilities) compared to the economy as a whole. Conserving energy reduces the energy bills paid by consumers and businesses, thereby enabling greater purchase of non-energy goods, equipment, and services. The result is a shift of economic activity away from energy supply industries and towards sectors of the economy, which employ more workers per dollar received. Regarding the different effects, less than 10% of the net jobs created are associated with direct investment in efficiency measures while more than 90% are associated with energy bill savings and re-spending of those savings."**[72]

When studying the potential of energy efficiency to create jobs in Colorado, the Southwest Energy Efficiency Project estimated that by 2025, for each one million dollars of investment in electrical energy efficiency, some jobs would be lost, and others created. Overall, there would be a net gain of 17 jobs created and an increase of $670,000 in wage and salary compensation.[78]

> **"Energy efficiency measures have enabled California households to redirect their expenditures toward other goods and services, creating about 1.5 million full time equivalency jobs with a total payroll of $45 billion, driven by well-documented household energy savings of $56 billion from 1972-2006."**[74]

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[77] Geller, Howard, John DeCicco, and Skip Laitner. Energy Efficiency and Job Creation. Rep. no. ED922. 1992. American Council for an Energy-Efficient Economy. http://www.aceee.org/pubs/ed922.htm
[78] Geller, Howard, and Marshall Goldberg. Energy Efficiency and Job Creation in Colorado. Rep. Apr. 2009. Southwest Energy Efficiency Project. 14 July 2009 http://www.swenergy.org/pubs/EE_and_Jobs_Creation_in_Colorado-April_2009.pdf
[79] Roland-Holst, David. Energy Efficiency, Innovation, and Job Creation in California. Rep. Oct. 2008. Center for Energy, Resources, and Economic Stability. 13 July 2009 http://www.nextten.org/next10/pdf/report_eijc/UCB_Energy_Innovation_and_Job_Creation_10-20-08.pdf.

The impact of energy efficiency on jobs in California has been significant: total job creation from household energy efficiency in CA from 1972-2007 was 1,463,611 new jobs. In 2007 alone, total job creation from household energy efficiency in CA was 434,898. Economic impact of these jobs has also been dramatic: total employee compensation gains from household energy efficiency in California from 1972 to 2007 was nearly $45 billion in year 2000 U.S. dollars. Total household savings from energy efficiency in California between 1972 and 2006 was $56 billion. In 2007 alone, household savings have been over $15 billion.[80]

Similar calculations for Colorado have concluded that the renewable energy industry has created 4,415 direct and 10,075 total jobs and over $1 billion in new revenue in 2007. One wind turbine manufacturer has added over 2,500 jobs in Colorado in a single year.[81]

[80] Ibid.
[81] http://www.coloradoconstructionmag.com/features/archive/2009/0709_Ca_Vestas.asp

Economic Multipliers

Sierra Business Council, a progressive chamber of commerce serving the Sierra Nevada region of California and Nevada, uses their economic multipliers – the number of times a dollar is spent in one region before leaving the region – as a measurement of how "leaky" a regional economy is. The Council phrased their strategy for building a more robust local economy as "plugging the leaks." They found the economic multiplier for the Sierra Nevada region to be 1.96 – i.e. dollars spent locally revolve in the local community twice, before leaving to pay for things like imported energy, thus doubling their buying power, as compared to dollars spent directly on imported items like coal, gasoline, or kiwi fruit.[82]

According to the University of Arkansas Extension Service, as cited in *How Communities Can Use Multipliers for Planning*, there are four types of multipliers: output (total change in local sales), employment, income (total increase in local income), and value added (additional value gained from more economic activity, e.g. taxes).[83]

One simple way to quantify economic multipliers is called Type III multipliers – a simple ratio of (Direct + Indirect + Induced effects)/Direct Effects.

Although not the primary topic of this report, more in-depth discussion of economic multipliers can be obtained from the US Bureau of Economic Analysis, which has created a handbook called Regional Input-Output Modeling System (RIMS II).
http://www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf

California's regional factors are between 1.5 and 2.5, so this report uses 2.0 as a basic multiplier. Matching this with the California numbers above would indicate that California gained $30 billion in net benefits from energy efficiency investments in 2007 alone. Similar benefits are available to all regions in the U.S.

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[82] The Sierra Business Council obtained their data from the Minnesota IMPLAN group, who offer an input-output systems software program for creating economic impact models: http://www.implan.com/library/documents/implan_io_system_description.pdf
[83] http://www.uaex.edu/other_areas/publications/pdf/fscdd-6.pdf

Health and Environmental Impacts

While the direct health impacts of any particular coal plant are highly variable, depending on the size, age, and location of the plant, all coal plants bear their proportionate share of the impacts of mining and transporting coal. These impacts are significant, due largely to the severe diseases that affect many coal miners in their later years, such as Black Lung Disease. Further, the aggregate, national impacts of small particulate matter alone (specifically, "$PM_{2.5}$" which refers to particulate matter smaller than 2.5 microns that can pass into the human bloodstream through the lungs, due to its small size) include nearly 24,000 premature deaths, and nearly $3 billion per year in related health costs. Add to that the as-yet-un-quantified costs of the health effects from coal ash and other toxic wastes associated with coal plants, and the total costs avoided by phasing out existing coal plants would provide significantly increased benefits to financial calculations.

Living near coal

Living in a community where coal is either mined or processed is a serious health risk. Coal mining communities experience almost 11,000 more deaths each year compared with other communities nationwide.[84] Of these deaths, approximately 2,300 are related to environmental factors such as pollution of water and air made worse by mining.[85] The extraction and production of coal emits pollutants such as mercury, sulfates (SO_x), nitrates (NO_x), carbon monoxide (CO), fine particle matter ($PM_{2.5}$) and large particle matter (PM_{10}).

[84] Hendryx, Michael. Ahern, Melissa. *Mortaility in Appalachian Coal Mining Regions: The Value of Statistical Life Lost.* Public Health Reports. July-August 2009.
[85] (Hendryx 2002)

Coal mining

In addition to the risks of death from insufficient mine safety,[86] coal miners are exposed to high levels of coal dust, which is damaging to the respiratory system. Some coal dust contains particles of quartz, the agent responsible for causing Coal Miner's Pneumoconiosis, or Black Lung.[87] Miners who are stricken with Black Lung experience shortness of breath, obstruction of airways, severe cough, and death. In the United States, among the 104,824 total coal miners, 4.5%, or 4,717 miners were affected by Black Lung. Over 10,000 miners have died from Black Lung in the past ten years. About 0.2% of coal miners are diagnosed with Progressive Massive Fibrosis, an advanced form of Pneumoconiosis, where lesions are formed in the lungs causing shortness of breath and extreme pain. Between 1968 and 1992, more than 59,000 deaths – all male -- were attributed to Black Lung.[88] Coal mining companies routinely include the costs of treating Black Lung as a separate line-item expense in their budgets. A social consensus seems to have been reached, whereby it is assumed that the suffering and deaths of coal miners from Black Lung is an acceptable sacrifice for providing energy. This tacit agreement apparently was achieved during the 19th Century, so most Americans are not aware of the deaths and suffering caused indirectly, when they switch on a light, a computer, or a microwave oven.

[86] http://coalmountain.wordpress.com/2009/05/13/the-crandall-canyon-mine-disaster/
[87] American Lung Association. *Coal Dust.* 2009. http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=35990
[88] ibid.

Mercury

Coal plants are responsible for about 65% of all mercury air emissions.[89,90] When coal is burned, mercury is released into the air, eventually making its way down to earth. It then contaminates the waterways, seeping into resident fish populations. Humans are exposed to the mercury by consuming the contaminated fish.[91] Exposure to mercury can cause sensory impairment in vision, speech, and hearing. It can impair senses to cause a lack of coordination. It can also cause kidney damage, personality changes, and in extreme exposure, death.[92] Mercury exposure is particularly dangerous to pregnant women and young children because it penetrates the nervous system and causes developmental disorders.[93] Approximately one out of every six women of childbearing age has an unsafe level of mercury in her blood.[94] Between 300,000 and 600,000 children are at risk for severe neurological and developmental impairment due to mercury exposure each year.[95] Mercury found in emissions from coal-burning can lead to other serious health impacts, especially in medically sensitive individuals such as pregnant women, children, and older adults. For every doubling of mercury concentration exposure to a fetus, it will lose 1.5 IQ points.[96] The actual cost of methyl mercury exposure from American coal-fired power plant emissions ranges from $0.4 to $15.8 billion annually.[97] The effects of air pollutants emitted by coal-fired power plants also can include asthma attacks, respiratory disease, heart disease, higher risk of cancer, and have been shown to retard cognitive development and stunt lung growth in children.[98]

[89] PSR (Physicians for Social Responsibility).*Coal-Fired Power Plants: Understanding the Health Costs of a Dirty Energy Source.* 2009.
[90] U.S. Environmental Protection Agency, ìU.S. EPA Toxics Release Inventory Reporting Year 2005 Public Data Release.î Section B. http://epa.gov/tri/tridata/tri05/pdfs/eReport.pdf
[91] Green America Climate Action. "*Coal: Dirty Energy*." http://www.coopamerica.org/programs/climate/dirtyenergy/coal/whydirty.cfm
[92] Environmental Protection Agency. "*Mercury: Basic Information.*" 20 May 2009. http://www.epa.gov/mercury/about.htm
[93] Ibid.
[94] U.S. Centers for Disease Control and Prevention. *Blood and hair mercury levels in young children and women of childbearing age in the United States*, 1999. Morbidity and Mortality Weekly, March 2, 2001; Mahaffey KR, U.S. Environmental Protection Agency. *Methylmercury: Epedimiology Update*. Presentation given at the National Forum on Contaminants in Fish. San Diego, CA. January 26th, 2004. http://www.epa.gov/waterscience/fish/forum/2004/presentations/monday/mahaffey.pdf.
[95] PSR 2009, Op cit.
[96] Budtz-Jorgensen E, et al., *Estimation of Health Effects of Prenatal Methylmercury Exposure Using Structural Equation Models.* Environmental Health. 2002;1(1):2.
[97] Seigneur C, et al., *Global Source Attributions for Mercury Deposition in the United States.* Environmental Science Technology. 2004;38(2):555–569.
[98] Clean Air Task Force for Clear the Air and the Physicians for Social Responsibility *Children at Risk, How Air Pollution from Power Plants Threatens the Health of America's Children*, May 2002

Coal Ash

In October 2000, in Martin County, Kentucky, and again in 2008, in Tennessee, a dam for a lake containing coal ash burst, releasing millions gallons of coal waste into the local river and its tributaries. Many miles of the rivers were choked with lava-like sludge that killed all fish and other river life. The spills affected thousands of people and their residences. Cleanup is expected to cost millions of dollars.[99] The more recent spill was described as follows: "The Kingston plant, for instance, primarily uses a low-sulfur coal and has scrubbers to capture nitrogen oxides, yet in 2007 its stacks still vented approximately 50,000 tons of sulfur dioxide, 12,000 tons of nitrogen oxides, 1,700 tons of hydrochloric acid, 329 tons of sulfuric acid, and ten tons of ammonia, as well as lesser (though not insignificant) amounts of arsenic, barium, chromium, cobalt, copper, lead, mercury, nickel, selenium, vanadium, and zinc. …Coal plants will create 130 million tons, ballpark, of ash each year… local property values have plummeted: by April, the TVA had spent nearly $20 million buying dozens of properties (off of local landowners affected by the disaster)."[100]

The substances that are left over in coal ash, after coal is burned, contain heavy metals that are toxic, and can easily leach into water supplies both above and below the ground. Because coal ash is treated as ordinary household waste and is not regulated, this solid waste loads landfills with toxic pollution. It destroys ecosystems and water quality at disposal sites where leakage and seepage points are not mitigated. Studies have shown that coal ash carries 100 times more radioactivity into the surrounding environment than a nuclear power plant.[101]

[99] Keating, Martha. Baum, Ellen. Hennen, Amy. *Cradle to Grave: The Environmental Impacts from Coal.* Clean Air Task Force. June, 2001. http://www.catf.us/publications/reports/Cradle_to_Grave.pdf
[100] GQ Magazine, October, 2009: http://men.style.com/gq/features/full?id=content_9277
[101] *Coal Ash Is More Radioactive than Nuclear Waste*. Scientific American, 2007.

Particulate Matter

According to the American Lung Association, more than 93 million Americans live in areas where they are exposed to unhealthy levels of particulate matter; and more than 54 million people live in regions with levels that are harmful year-round.[102] Particulate matter can cause asthma attacks, lung tissue damage, stroke, heart attack, and premature death.[103,104] Children and the elderly are more at risk, because their immune systems are weaker.[105]

Pollution from coal-burning power plants can lead to infrastructure impacts, such as the collection of particulate matter on buildings and cars. Additionally, coal plant infrastructure such as pipelines and boilers must be properly maintained and updated to avoid further exposure.

Table 18: Health Impacts of Coal Particulate Pollution[106]

Premature Death	23, 600
Heart Attacks	38, 200
Asthma Attacks	554,000
Hospital Admissions	21,850
Emergency Room Visits	26,000
Lost Work Days	3,186,000

[102] American Lung Association, *State of the Air: 2007.* 2007. http://www.lungusa2.org/embargo/sota07/ALA_SOTA_07.pdf
[103] Brook, RD, et al. *Air Pollution and Cardiovascular Disease: A Statement for Healthcare Professionals From the Expert Panel on Population and Prevention Science of the American Heart Association.* Circulation, 2004;109:2655-2671; Hong, Y.-C.,et al. *Effects of Air Pollutants on Acute Stroke Mortality.* Environ. Health Perspect, 2002; Vol. 110, pp. 187-191; also Zanobetti A, Schwartz J. *The Effect of Particulate Air Pollution on Emergency Admissions for Myocardial Infarction: A Multicity Case-Crossover Analysis*. Environ Health Perspec., 2005; pp. 113:978-982.
[104] PSR, 2009, op. cit.
[105] Clean air task force. *Cradle to the Grave: The Environmental Impacts of Coal*. June 2001. http://www.catf.us/publications/reports/Cradle_to_Grave.pdf
[106] PSR 2009, op. cit.

Additional Costs of Pollution from Burning Coal

The average cost of health-related damages associated with fine particulate matter from coal-fired power plants ranges widely, from $30,000 to $5,000,000 per ton of $PM_{2.5}$. The cost to society for each ton of SO_2 is between $6,000 and $50,000. For NO_x, the cost varies between $5,000 and $15,000 per ton. For each kilowatt-hour of electricity generated, the health-related damages cost has been shown to be $0.02 to $1.57. The variability in cost is attributed to the difference in exposure, for example the distance a person lives from a coal plant or mine, or the number of plants or mines in a region.[107]

The EPA standard for calculating the value of a statistical life (VSL) is $5.5 million.[108] Deaths in coal mining areas annually range from 3,975 to 10,923, depending on the year and comparison group studied.[109] The corresponding VSL for these deaths ranges from $18.563 billion to $84.544 billion, with an overall median of $50.010 billion -- significantly greater than the $8.088 billion economic contribution of coal mining.[110]

6.7 million children suffer from pediatric asthma in the US and 30% of which is environmentally attributed.[111] Doctors estimate the annual cost of environmentally induced pediatric asthma at $2.7 billion.[112]

Table 19: Health Costs of Pollution from Burning Coal

		Average cost of 1 day of hospital treatment	Average number of days treated in hospital	Total costs/length of stay	**Total** **(in millions)**
Heart Attacks	38, 200	$2, 307.92[113]	5[114]	$11,539.60	**$441**
Asthma Attacks	554,000	$816.32[115]	3.8[116]	$3,102.53	**$1,719**
Hospital Admissions	21,850	$1,121.59[117]	6.95[118]	$7,795.05	**$170**
Emergency Room Visits	26,000	$560[119]	1	$560	**$15**
Lost Work Days	3,186,000	@ $12.50 per hour = $100/day		$318,600,000	**$319**
				Total	**$2,663**

[107] Levy, Jonathan. Baxter, Lisa. Schwartz, Joel. "*Uncertainty and Variability in Health-Related Damages from Coal-Fired Power Plants in the United States.*" Risk Analysis. 2009.
[108] ibid.
[109] Hendryx, M. and M. Ahern, 2009,op. cit.
[110] PSR, 2009, op. cit.
[111] Landrigan, Phillip., Schechter, Clyde. *"Environmental Pollutants and Disease in American Children: Estimates of morbidity, Mortality, and Costs for Lead Poisoning, Asthma, Cancer, and developmental Disabilities."* Asthma. Environmental Health Perspectives (Journal). 1 July 2002.
[112] (Green Climate Action 2009)
[113] Candrilli, Sean. Mauskopf, Josephine. *How Much Does a Hospital Day Cost?* RTI Health Solutions: Research Triangle Park. North Carolina. 2002.
[114] Ibid.
[115] Ibid.
[116] Ibid.
[117] Ibid.
[118] Ibid.
[119] Machlin, Steven. *Expenses for a Hospital Emergency Room Visit.* Agency for Healthcare and Research Quality. January 2006.

Other Externalized Impacts

As mentioned above, infrastructure impacts due to pollution from coal plants include buildings, car paint, archaeological resources, gaskets and seals, and more.

Real estate values have been shown to decrease in areas of noxious facilities such as coal and nuclear power plants. This is due to the risk of reduced air quality from coal emissions or an accidental spill of coal ash or nuclear waste. Rather than the asset they may have been considered when built, coal-fired power plants have become a "disamenity" that can hurt cultural and civic pride in a community. In part, this is why the few remaining proposed coal plants tend to be sited in remote locations, like NGS.[120]

Coal-burning power plants cause many other negative impacts, the costs for which have been "externalized." Ratepayers bear great financial risk, due to fuel and water price volatility, evolving regulations, legal fees from potential health lawsuits and lobbying against more stringent regulations. It is a little-known fact that once a coal plant is operational, ratepayers are commonly required to pay all of these costs, even if the plant never becomes operational or is phased out. There is also financial risk from new potential pollution control requirements, and reduced demand for coal-based power. These additional costs are often passed on to ratepayers in the form of higher utility prices.

Over time, if groundwater used for coal plant cooling systems becomes depleted, it becomes harder to subsist on the surrounding land. Especially in arid areas, this overuse can lead to increased water pumping costs and a drop in the water table, which makes irrigating and accessing drinking water more difficult. In some regions, this might be a reason to not pump additional groundwater, while in others, water rights may be secured to avoid over-use.[121]

The outdoor recreation industry provides an influx of revenue to many states that is irreplaceable. Many tourism areas rely on an undisturbed viewshed to help maintain a sense of place and draw visitors to a beautiful setting. Coal burning power plants can be seen as blemishes on a landscape and air-polluters, discouraging visitors from traveling to and spending time in these areas. According to the Outdoor Industry Foundation, outdoor recreation generates at least $730 billion each year, supporting nearly 6.5 million full-time jobs and $88 billion in annual state and national tax revenue.[122]

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[120] Clark, David and Nieves, Leslie. *An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values,* Presented at the 38th North American Meeting of the Regional Science Association, November 1991.
[121] Ehlen, Judy et al. *Humans as Geologic Agents,* Geologic Society of America, 2005.
[122] http://www.docstoc.com/docs/946713/Active-outdoor-recreation-economy

Estimates of NEPA-based Life Cycle Accounting

Long-term impacts of coal burning can be avoided by a shift to more efficient uses of renewable sources of energy. Ecosystems provide services to humans that are intrinsically valuable but not often measured in terms of their financial value. Environmental impacts on these ecosystem services can occur over an entire product life cycle. Within the National Environmental Policy Act (NEPA) framework, communities can account for those services essential for survival, such as providing food, purifying fresh water, regulating climate and forming soil.[123] Ecosystems will sustain less impact if communities switch to renewable energy sources.

Projections of reduced environmental impacts resulting from the shifting of coal-derived jobs and energy to efficiency and renewable sources of supply include:

Surface and Groundwater: Surface and groundwater will not be polluted by point sources of pollution such as the smokestacks at the coal-fired power plant, or by non-point sources that are hard to monitor, such as seepage from disposal sites. Cleaner groundwater is easier to prepare for drinking and irrigation, saving money and avoiding building new, costly water treatment plants or spending millions on mitigation, as has been required on military bases and Superfund sites. A reduction in pollution to surface water and groundwater is good for forests and rivers, which serve as filters for water later used for irrigation and which also support biodiversity.

Air: Air quality will improve over time as emissions from coal-fired power plants are reduced and forests and oceans can process and purify polluted air. Healthier forests and oceans improve human and ecosystem health, saving on costly medical bills, and the health of wildlife and plant life.

Vegetation: With renewable energy, acid rain due to SO_x and NO_x air pollution would decrease, returning forests to optimum health, maintaining biodiversity, and supporting local food sources and economies. Coal-fired power plants accounted for 66% of SO_2 pollution in 2003.[124]

Wildlife: Without pollution from coal plants, wildlife will have cleaner air, less destruction of habitat due to mining, and reduced levels of mercury in their bloodstreams.

Fish: Rivers and groundwater feed oceans and lakes. If rivers carry cleaner water, and if rainwater is less toxic, ocean and freshwater fish will struggle less to survive due to cleaner water and less toxic food sources. In 2008, the fishing industry was responsible for over $4 billion in revenues, which could be lost if fish become too laden with mercury to consume, or cannot survive in polluted waters.[125]

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[123] The Katoomba Group, *Payments for Ecosystem Services, Getting Started: A Primer,* Forest Trends, 2008
[124] U.S. Environmental Protection Agency, *National Air Quality and Emissions Trends Report.* 2003. Appendix A.
[125] NOAA Fisheries Office of Science and Management, Fisheries Statistics Division, http://www.st.nmfs.noaa.gov/st1/index.html, visited on August 18, 2009.

Habitat Quality or Condition: The most direct effects on various species from coal-burning power plants are destruction of habitat due to mining and loss of food sources due to pollution. Although some loss of habitat may occur with alternative sources of energy, less pollution means that wildlife will be able to cohabitate with an energy plant that is not burning coal. Wind farms cause minimal damage to habitats, as the majority of the space wind turbines take up is vertical, and new turbine/blade designs do not harm birds. Designing and siting of solar plants in the desert must be carefully evaluated to minimize impacts on sensitive or endangered species.

Cultural Resources affected by pollution, mining, and other aspects of coal plant supply and operation include prehistoric and historic archaeological treasures, such as the degradation of the ancient ruins at Mesa Verde and the loss of mountains, rivers, and fisheries in Appalachia. Section106 of the National Historic Preservation Act protects these types of resources.

Environmental Justice: Though promoted as providing jobs and revenue, the citing of hazardous carbon sequestration projects on tribal lands is considered by many residents to be a form of environmental racism. Conversely, many families, companies, and communities that depend on the coal economy consider alternatives as threatening to their security. Environmental justice requires that these factors be considered in determining the most equitable strategies for transitions to benign technologies, and that strategies chosen include proper allocation of resources to ensure security and stability for communities in transition.

Displacement of Residents and Businesses must be considered to determine how many would be affected by each alternative – in particular, which people, companies and communities would be affected by a transition away from coal, and whether adequate retraining, relocation, and reallocation opportunities exist. Although it has been documented (as shown above) that renewable technologies provide more jobs and economic multipliers than fossil fuels, careful planning will be required to make sure that impacts on livelihoods, profits, and community livability are benign, and no one gets abandoned.

Noise Impacts: Coal plants and coal mining operations can be loud. Some alternatives, such as solar photovoltaic systems are more silent, but others, such as some types of wind technologies, can produce noise impacts, which also must be considered when choosing where to locate facilities.

Visual Impacts of smokestacks to both stationary and mobile viewers have moved from the admirable engineering marvel of the 19th Century, to being considered as eyesores that reduce property values. However, it remains to be seen whether solar, wind, biomass, and geothermal options will be any less offensive to local and regional populations.

Visibility is affected both by NO_x and particulate matter (PM) emissions from burning coal. PM under 10 microns in width interact with light, disrupting visibility. In an August 24, 2009 letter to the EPA, the National Park Service (NPS) found that eleven of 156 identified Class I Federal areas, such as national and state parks, wildlife areas, national forests and monuments, lie within a 300-mile radius of Navajo Generating Station, and visibility in eleven of those sites is directly affected by the plant's pollution.

Land Use Compatibility: Concentrating solar plants in desert areas that are also sensitive habitat, or locations of wind or geothermal facilities on mountain top removal areas prior to remediation and restoration provide challenges and opportunities for local and regional planners. All types of energy generation require some land; so related issues of compatibility will remain, regardless of the strategies chosen.

The Cost of NEPA-based pollution mitigation

Impacts and costs of applying technology to mitigate these sources of pollution on the larger society and environment can be staggering. The National Park Service's cost estimates of reducing NO_x and PM pollution differ from EPA estimates.[126] For example, the EPA estimates that a reduction of 90 to 375 tons of PM would cost between $3 and $9 million annually -- up to $200 million in capital cost. The National Park Service's estimates for Four Corners Power Plant (FCPP), based on the same EPA Cost Control Model, are illustrated in Table 20, below.

Table 20: Capital Cost of Reducing Particulates at Four Corners Power Plant

	Total Capital Cost	Total Annual Cost	Cost Effectiveness
Unit 1	$18,508,764	$2,983,004	$1,558/ton
Unit 2	$18,508,764	$3,052,010	$1,469/ton
Unit 3	$22,187,577	$3,497,117	$1,684/ton
Unit 4	$52,788,968	$9,838,997	$1,185/ton
Unit 5	$52,788,968	$9,213,942	$1,357/ton

The NPS found that the cost of reducing NO_x and PM pollution to EPA compliant levels would be absorbed by the consumer, increasing their electricity costs. They estimate that NO_x pollution reduction at FCPP would increase electricity costs as little as $.001 per kWh and as much as $.016 per kWh. Particulate matter reduction technology at FCPP could cost consumers between $.003 and $.008 per kWh. The average household, consuming 10,656 kWh per year could see an additional $10 to $170 on their electricity bill annually.

In its August 24, 2009 letter to the EPA, the National Park Service reviewed the EPA assessment of NGS and made recommendations for improving the pollution reduction Best Available Retrofit Technology (BART) analysis on the two power plants. NPS concluded that Selective Catalytic Reduction (SCR) is "technically feasible, cost-effective, and will substantially improve visibility" in the eleven Class I areas affected by NGS. As NGS is the fifth largest source of NO_x pollution at 35,253 tons in 2007, there is ample room for improvement. NPS also determined that BART may not be the most cost-effective solution, but rather should act as part of a matrix of solutions that takes into account economic, environmental, technical, and energy factors. As with any issue, NPS recommends using a case-by-case approach to designing pollution mitigation solutions for power plants, rather than a blanket approach.[127] Other EPA estimates of the costs of NO_x emissions controls run as high as $0.06 - 0.07/kWh – more than $700 million over 7 years.[128]

[126] Unless otherwise indicated, mitigation statistics in this section are from EPA, *Assessment of Anticipated Visibility Improvements at Surrounding Class I Areas and Cost Effectiveness of Best Available Retrofit Technology for Four Corners Power Plant and Navajo Generating Station: Advanced Notice of Proposed Rulemaking*, August 2009.
[127] Bunyak, John, letter to EPA from NPS, August 24, 2009
[128] EPA Advance Notice of Proposed Rulemaking signed 8-19-09 (EPA-R09-OAR-2009-0598), page 33.

5. Electronic Dashboard Calculator

The electronic **Dashboard Calculator** that accompanies this report is designed as a reusable tool. It can be used to evaluate the benefits and return on investment of phasing out any existing U.S. coal plant. This enables users to replicate the calculations, to determine how fast the need for electricity provided by a coal-fired power plant could be eliminated or obtained from renewable sources in cost effective ways.

An important aspect of the calculation is to document how stakeholders can receive greater benefits from phasing out a coal plant than from operating it in a carbon- and water-constrained world.

The Dashboard Calculator provides various scenarios based on projections for the relevant costs and values of coal, CO_2, SO_2, NO_x, sulfur, water, and "green" electricity premiums, as well as different scenarios for varying percentages of efficiency and renewable technologies.

No attempt has been made to estimate net present value (NPV) for the various factors, in part because the diversity of years for source data makes this largely impractical. Differing lifecycle, variable interest, and appreciation/depreciation rates, as well as regional cost variations result in sufficient fluctuations that NPV, nominal, and levelised cost estimates and varying load capacities will be calculated more effectively on an individual basis, as this methodology is applied to specific plants in various regions. Nonetheless, this Dashboard Calculator offers an opportunity to review fundamental parameters in shifting from coal to clean energy, to quantify their general economic relationships, and is intended to stimulate more in-depth critical thinking and analysis.

The Dashboard Calculator also includes an illustrative sheet, using hypothetical numbers, to illustrate the kind of load capacity analysis that would be required to verify which types of efficiency and renewable sources of supply could match the load curve and profile of a base load coal plant.

The Dashboard Calculator can be downloaded from the web at:

www.natcapsolutions.org/coal/calculator.xls

Updated versions and assistance using the Calculator may be obtained by request via email to:

info@natcapsolutions.org

6. Conclusion and Recommendations

On the basis of this analysis Natural Capitalism Solutions has concluded that:

It is cost effective to provide the jobs and energy of existing coal plants,

through efficient use of renewable sources of energy.

In offering this conclusion, the authors recognize that there are many stakeholders involved in complex incentive structures, which provide equally complex motivations for all participants including (but not limited to):

- regulators,
- utility companies and their subsidiaries,
- tribes,
- other capital owners,
- financial institutions,
- rate payers, and
- workers, employees, and other concerned citizens.

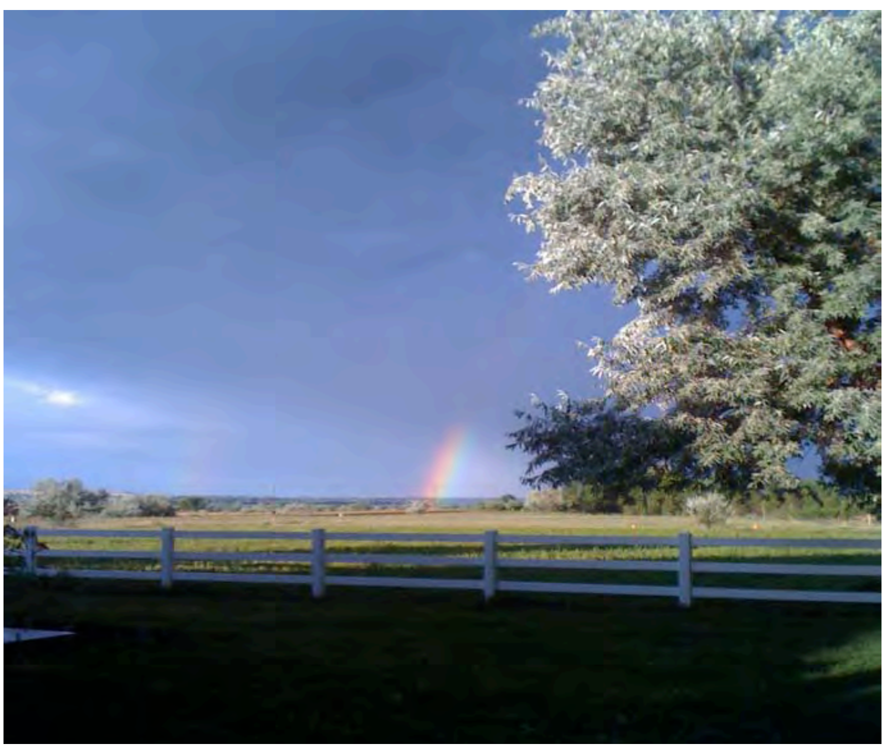
Therefore, Natural Capitalism Solutions recommends as a next step that diverse groups of stakeholders participate in an open dialogue to identify and remove barriers to phasing out existing coal plants, while providing services through efficient use of renewable sources of energy. Rapid and profitable repositioning of capital and equity, through creative incentive-based strategies can reduce costs, improve revenues, and decrease pollution, while creating green jobs and improving prosperity for local communities.

Though not possible within the specific scope and budget of the current report, Natural Capitalism Solutions further recommends that additional economic analyses be conducted, to demonstrate detailed scenarios, including calculations of net present value, levelised and nominal costs, capacity, load profiles, and other specific details that would be required to apply the recommended options to a specific coal plant.

Externalized health and ecosystem impacts are not currently included on profit and loss statements or on balance sheets, but rather are absorbed and paid for by regional constituencies or society as a whole. Therefore, these issues must also be considered from a whole systems perspective. Natural Capitalism Solutions recommends developing solutions that properly compensate existing capital owners, revenue interests, and those individuals communities, and regions, who rely on coal-based energy systems for their livelihoods, as well as those people and ecosystems impacted by the adverse effects of coal-based energy.

This report proposes a set of restructured economic assumptions, to document the value of eliminating the pollution, health, and economic impacts of existing coal plants and provide the same jobs and services with efficiency improvements and renewable energy sources.

If proponents took Navajo Generating Station offline, investing the resulting savings and revenues in efficiency improvements, wind, solar, geothermal, biomass, and other cost-effective, renewable, benign sources of meeting end-use needs, the combined values of pollution avoided, carbon credits, SO_x credits, NO_x credits, water saved for resale, money saved on coal fuel, "green" premium prices, avoided asthma and heart disease, jobs created, economic multipliers, and ecosystem services would exceed the amount required to eliminate the need for the coal plant.



Appendix 1. About Natural Capitalism Solutions

Natural Capitalism Solutions is recognized internationally for its work in the field of sustainability. Formed by Hunter Lovins, coauthor of the acclaimed book Natural Capitalism: The Next Industrial Revolution, Natural Capitalism Solutions has been at the forefront of identifying opportunities and developing innovative and practical ways to increase efficiency and economic sustainability for a long list of community, government and corporate clients.

In every organization, there are three levels of opportunity to improve profitability and sustainability:

1. **Buy Time through Increasing Efficiency:** by dramatically increasing the productivity of resources including energy, water, materials and people.

2. **Design for Sustainability:** by creatively using innovative green processes to eliminate waste and toxic, while delivering superior products and services.

3. **Manage for Regeneration of People and Place:** by continuously restoring & enhancing communities' natural and human capital, while increasing profitability and competitive advantage.

Over the years, Natural Capitalism Solutions has developed a series of tools and strategies to support leaders in successfully engaging local citizens, organizations, and other government agencies, to measurably improve sustainability performance.

Natural Capitalism Solutions' past high-leverage initiatives include:

- Establishing sustainability as a field through the book Natural Capitalism.
- Advising the U.S. Environmental Protection Agency (EPA) on development and implementation of the ENERGY STAR system.
- Natural Capitalism provided advice and counsel to the California Energy Commission on energy efficiency, consumer electronics, plug loads, and a wide variety of other topics.
- Natural Capitalism assisted the California Public Utilities Commission in developing and implementing the Million Solar Roofs program.
- Natural Capitalism participated in the formation of the U.S. Green Building Council (USGB), and subsequently advised USGBC in the development of the Leadership in Energy and Environmental Design (LEED) system.
- Natural Capitalism Senior Consultant Paul Sheldon assisted in developing and implementing pioneering legislation that limited smoking in public places in Aspen and in California.
- Natural Capitalism advised the founders of the Chicago Climate Exchange (CCX), including writing the CCX membership manual.
- Development of the city of Berkeley 2006 sustainability plan, including a new nonprofit organization to facilitate actions that were difficult for the city itself to accomplish. This resulted in significant behavioral changes in city operations, business commitments, and non-profit collaboration. One of the results was the precursor to Boulder County's 1A initiative.
- Natural Capitalism team members advised the government of Canada (Natural Resources Canada) on formulating and setting policy to regulate energy efficiency in consumer electronics and office equipment.

Appendix 2. Project Leadership

President: L. Hunter Lovins

Hunter Lovins is President and founder of Natural Capitalism Solutions. Trained as a sociologist and lawyer (JD), she co-founded the California Conservation Project (TreePeople) and subsequently Rocky Mountain Institute, which she led for 20 years. Lovins has consulted for scores of governments worldwide, communities and for large and small companies, including the International Finance Corporation, Royal Dutch Shell, Interface, PortionPac and Chicago Manufacturing Center. Governmental clients include Afghanistan, Australia, Canada, China, Germany, Jamaica and New Zealand. Within the United States, she has consulted for the Presidential Cabinet, Department of Defense, Environmental Protection Agency, Department of Energy and numerous state and local agencies.

Chief Executive Officer: Jeff Hohensee

Jeff is a change management expert who has worked in business, education and sustainability for over twenty-five years. He started his career in corporate finance working for Barclays American Business Credit and Fuji Bank subsidiary Heller Financial. He specialized in time and motion studies, department reorganizations, cash management, financial analysis and negotiations. Leaving the private sector to teach, he worked as a public school teacher and as an adjunct faculty member at Citrus College. Jeff frequently advises on environmental sustainability, community building and business development, and has extensive experience in curriculum development, civic engagement, project management, business planning, strategic planning, focus groups, organizational development and change management.

Senior Consultant: Paul Sheldon

Paul specializes in organizational development, and staff training. He consults widely for businesses, governments, non-profit groups and philanthropists, as well as having served as Senior Manager of Policy and Research for Ecos Consulting, where he co-authored Diné CARE's 2007 Energy and Economic Alternatives to the Desert Rock Energy Project report. He is formerly a Senior Underwriting Consultant to California's State Workers' Compensation Insurance Fund, where he served as liaison to the Public Utilities Commission, Contractors' State License Board, and the Department of Motor Vehicles. His clients have included the California Energy Commission, U.S.E.P.A., Natural Resources Canada, the Natural Resources Defense Council, The Nature Conservancy, the U.S. Air Force, General Motors, Bank of America, Muzak, Suzuki Motors and a number of cities and local organizations. Paul also has extensive business experience in wholesale and retail travel, hospitality, real estate, personnel and insurance industries. He helped to organize the Los Angeles-based TreePeople, the Rocky Mountain Institute, Friends of the Los Angeles River, and many other non-profit organizations. Paul holds B.A. and M.A. degrees in human development and a lifetime community college teaching credential in Business and Industrial Management. Since 2003, Paul has worked closely with Hunter Lovins, co-teaching "Principles of Sustainable Business Management," "Implementing Sustainable Business Practices," and "Effective Management, Communication and Action" at Presidio School of Management, one of the first fully accredited M.B.A. programs in Sustainable Management.

Research Director: Nick Sterling

Nick provides research leadership with client projects, deliverables and sustainability consulting. Prior to working with NCS, he worked with Pacific Outdoor Equipment as a sustainability advisor, helping POE to address their carbon footprint and shipping impacts. Additionally Nick worked with an economic research and consulting firm, specializing in energy and waste management, as well as a river and wetland restoration firm located in the Front Range of Colorado. Nick holds B.S. degrees in Environmental Studies and Physical Geography from the University of Colorado-Boulder (CU).

Project Engineer: Emily Evans

Emily's duties include client development, proposals, writing, and research. In addition to this report, Emily has recently co-authored a book (with Hunter Lovins and Catherine Greener) for the United Nations Industrial Development Organization (UNIDO), redefining the industrial, manufacturing economy of Asia using the Principles of Natural Capitalism. Prior to joining Natural Capitalism Solutions, Emily worked with Brown and Caldwell as a consulting environmental engineer. She created and led the internal sustainability office program and was a key player in developing and marketing the external environmental sustainability and performance service line. She was also the assistant coordinator for two non-profit watershed groups and helped oversee and manage water quality studies. Before working with Brown and Caldwell, Emily worked as an engineering consultant with Cameron-Cole, specializing in the remediation of hydrocarbon plumes and industrial wastewater treatment design. Emily completed her B.S in environmental engineering from the University of Colorado at Boulder (CU-Boulder) in 2002 and her M.S. in environmental engineering at CU-Boulder in 2005.