PUBLIC HEALTH BENEFITS OF CONVERTING THE RIVERSIDE COAL PLANT TO NATURAL GAS

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July 2002

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Executive Summary

The owner of the Riverside coal plant in Northeast Minneapolis, Xcel Energy, has put forth a proposal to convert the plant from coal-fired to natural gas. An understanding of the current health impacts of the Riverside plant, compared with impacts from conversion to natural gas, will help decision-makers weigh the costs and benefits of this proposal. An evaluation of the proposal's impact on surrounding communities is particularly timely as Minneapolis considers the re-development of its Upper Mississippi River Corridor, and as neighborhood residents show increasing concern for pollution from the Riverside plant.

This paper reports the estimated public health impacts of the Riverside coal plant and compares them to the estimated impacts of converting the plant to natural gas. The results are the central estimates from a masters thesis completed at the Humphrey Institute, University of Minnesota. The study was done for just one pollutant, particulate matter, more commonly known as "soot".

The Riverside plant was first built in the early part of the 20th century, with the latest boiler completed in 1963. Emissions of most pollutants far exceed levels currently achieved by modern coal plants. In addition, the plant is located in a high-density population center. This results in health damages that are higher than those of any other power plant in the state.

The study predicts that each year the Riverside plant is responsible for approximately:

- 8 premature deaths;
- 15 new cases of adult chronic bronchitis;
- 102 new cases of child acute bronchitis;
- 4 hospital admissions from respiratory causes;
- 84 emergency room visits;
- 1,180 asthma attack days;
- 17,100 restricted activity days; and
- 44,300 respiratory symptom days.

These impacts occur in Minnesota and surrounding states, with roughly one-third of the total impacts occurring within Hennepin County. The approximate economic value of these health impacts is estimated at $57.4 million, or about 2.8 cents for every kilowatt-hour of electricity generated by the plant.

The study concludes that a conversion of the Riverside plant to natural gas could reduce these public health impacts by over 90 percent. At the same time, mercury emissions could be nearly eliminated and carbon dioxide emissions reduced by approximately two thirds.

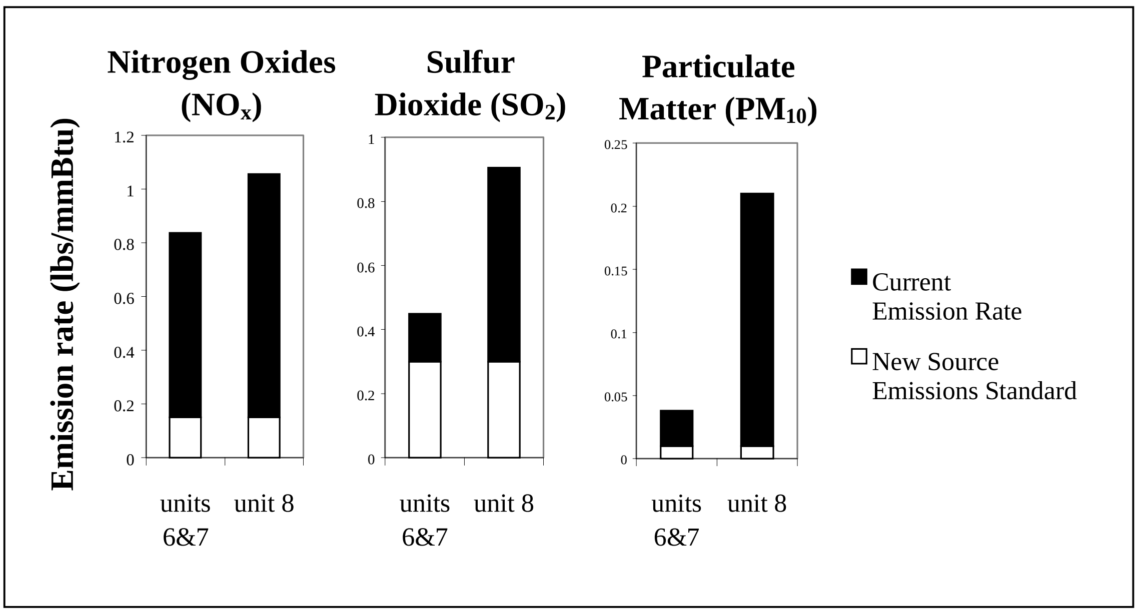
Introduction

Originally built with horse-drawn equipment in 1911, the Riverside coal-fired plant in Northeast Minneapolis has been important to the economic development of Minneapolis. Referred to as the "mother plant," it was the main supplier of Minneapolis' electricity for many years. The growth of Minneapolis has been matched by the growth of the Riverside plant. A total of eight units have been built over the years. The two current generators, with a total rated capacity of over 400 megawatts, were built in 1964 and 1986. Three boilers produce steam for the generators. These boilers were completed in 1948 (boiler 6), 1950 (boiler 7) and 1963 (boiler 8).

Emissions concerns

Because the boilers were built before the passage of the original Clean Air Act over 30 years ago, they are exempt ("grandfathered") from implementing the strict pollution control standards required by the Clean Air Act. As a result, emissions from the Riverside plant are as much as 21 times greater than the emissions limits required of new plants by the Clean Air Act, as shown in Figure 1.

Figure 1: Riverside Emissions Rates Compared with New Source Standards[1]



Because scientific studies show that health and environmental damages for coal plant emissions are much greater than previously thought, the high emissions rate of the Riverside plant seems increasingly unacceptable for a high population density area. Over 100 neighborhood residents attended a public hearing in December of 2001 concerning renewal of the plant's operating license, most demanding that the plant reduce emissions.

[1] Source: Minnesota Pollution Control Agency and U.S. Environmental Protection Agency, average emissions for 1995-1997.

Adding to the public momentum to clean up the plant is the City of Minneapolis' plan to redevelop the Upper Mississippi River Corridor. The city's Master Plan for this area, entitled "Above the Falls," calls for transitioning the riverfront from its current use as an industrial area to a continuous park system. The vision of the Master Plan is to "create an amenity that will extend the intrinsic value of the river into local neighborhoods and the region, and provide new destinations for visitors that celebrate Minneapolis as a city on the Mississippi."[2] Heavy industries, such as the Riverside plant, stand in the way of this redevelopment.

According to the plan, the storage piles for the coal and coal ash at the Riverside plant are the main drawback to redevelopment of the region around the plant. The plan also states, however, that should the plant be converted to natural gas, these areas would become prime candidates for redevelopment.

Conversion to natural gas proposed as part of emissions reduction plan

Xcel Energy, as part of a merger agreement, was required to consider options for reducing pollution at its metro plants, including converting the plants to natural gas. Offering a dramatic reduction in pollutants, natural gas conversion more closely matches the city's master plan for the region. Converting to natural gas would also virtually eliminate emissions of mercury (a potent neurotoxin) and dramatically reduce carbon dioxide (a powerful global warming gas) and other pollutants.

In May 2002, Xcel Energy announced their intention to convert both the High Bridge (in St. Paul) and the Riverside coal plants to natural gas, as well as install pollution control equipment at the Allen S. King plant (in Bayport). At a cost of $226 million dollars, the Riverside conversion will increase the capacity of the plant from about 360 megawatts to 439 megawatts. The Riverside conversion is due to be completed in 2009.[3]

Scope of this paper

One of the largest impacts to human health from the Riverside plant is from emissions of particulate matter (PM), commonly referred to as "soot". Using a model developed for a master's thesis at the University of Minnesota's Humphrey Institute, this paper estimates the annual health impacts of Riverside's primary and secondary PM emissions.[4] The paper was peer-reviewed for accuracy in the presentation of the results.[5]

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[2] See www.ci.minneapolis.mn.us/citywork/planning/planpubs/above-falls.

[3] See Xcel Energy's "Proposed Selection of Emission Reduction Projects," submitted to the MN Public Utilities Commission May 3, 2002; available at: www.xcelenergy.com/Environment/RegulatoryFilings.asp

[4] This paper is derived from a master's thesis from the University of Minnesota's Humphrey Institute completed in October 2000, by Carl Nelson and entitled "The Public Health Impacts of Particulate Emissions from Coal-Fired Power Plants in Minnesota." The complete thesis contains a detailed description of the model, methodology and data sources presented in this paper, and can be downloaded at www.mnproject.org (click on "Health impacts of coal plants").

[5] Reviewers included: Dr. Sandra Archibald, University of Minnesota Humphrey Institute; Dr. Ken Sexton, University of Minnesota Dept. of Public Health; and Dr. Gregory Pratt, Minnesota Pollution Control Agency.

Health and Environmental Impacts of Coal-Fired Power Plants

The combustion of coal in power plants results in impacts that negatively affect many communities and ecosystems. The impacts range from the effect on fish populations due to the release of high-temperature wastewater into rivers and lakes to groundwater contamination from the disposal of coal ash.

Emissions of air pollutants are one of the greatest impacts of coal-fired power plants. These impacts can occur in the immediate vicinity of the plant as well as far from the source of the emissions, affecting communities and ecosystems many hundreds of miles from the power plant. There are five main emissions of concern: particulate matter, sulfur dioxide, nitrogen oxides, mercury, and carbon dioxide.[6] Table 1 summarizes the impacts from these pollutants, and they are described briefly in the text that follows.

Table 1: Major Environmental and Health Impacts of Coal Plant Emissions[7]

Primary emission	Secondary emissions	Environmental / health impacts
Particulate Matter (PM)		♦ lung damage and respiratory problems ♦ damage to materials ♦ reduction in visibility
Sulfur Dioxide (SO_2)		♦ acid rain: ecosystem and materials damage
	sulfates (PM)	(similar health impacts as particulate matter)
Nitrogen Oxides (NO_x)		♦ headaches, minor respiratory problems ♦ acid rain: ecosystem and materials damage
	nitrates (PM)	(similar health impacts as particulate matter)
	ozone (O_3)	♦ lung damage and respiratory problems ♦ crop damage ♦ damage to materials ♦ damage to forests and wildlife
Mercury (Hg)		♦ damage to nervous systems ♦ reproductive problems in wildlife
Carbon Dioxide (CO_2)		♦ impacts from climate change (loss of boreal forest, increased flooding and heat waves, increase in agricultural pests, etc.)

Particulate Matter / Soot

Particulate matter (PM), more commonly known as "soot," consists of tiny particles emitted from the stack that remain suspended in the air. The particles can lodge deep in human lungs and do significant respiratory damage. PM is formed both directly and indirectly from the combustion process.

[6] Other air pollutants from coal plants, emitted at lesser rates, include carbon monoxide, lead, benzene, dioxins, other metals and other air toxins. These pollutants also pose environmental and health risks.

[7] Derived from page 4 of the original report (cited in footnote 3).

Sulfur Dioxide and Nitrogen Oxides

In addition to direct emissions of PM, sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are chemically transformed into sulfates and nitrates, both forms of PM, after leaving the stack. Both SO_2 and NO_x also cause acid rain, which leads to ecological and materials damages. NO_x have also been associated with respiratory and other health problems. In addition, NO_x are transformed into ground-level ozone, or smog, in the presence of sunlight and other catalysts. Besides being aesthetically unpleasing, ground-level ozone is a significant risk factor for a range of respiratory problems including asthma. Ozone is also responsible for damaging agricultural crops.

Mercury

Coal-fired power plants are the single largest source of mercury emissions in Minnesota. Mercury emissions are transported downwind and eventually deposited in soil and lakes. Mercury then becomes concentrated in fish, becoming a risk when people and predatory wildlife ingest the fish. Mercury is a neurotoxin, of particular concern for sensitive populations, especially pregnant and nursing women, children and unborn babies. Those with mercury poisoning suffer from impaired nervous system development, which in turn results in delayed mental development and deficiencies in motor function, attention and memory. The concentration of mercury in lakes has resulted in more than 800 Minnesota lakes receiving fish consumption advisories from the Minnesota Department of Health.

Carbon Dioxide

Carbon dioxide (CO_2) is the most significant greenhouse gas contributing to climate change, and coal-fired power plants are the single largest source of CO_2 in Minnesota. The Intergovernmental Panel on Climate Change (IPCC), a group representing the world's preeminent climate scientists and technical experts, has projected a global average temperature increase over the next century in the range of 2 -10° F.[8] A recent National Academy of Sciences review of the IPCC work, commissioned by the Bush Administration, confirms this finding.[9] Some of the projected impacts of this temperature increase include: a projected sea level rise of 20 inches; an increase in the range and severity of agricultural pests; an increase in the frequency and severity of severe and catastrophic weather events; and a poleward migration of the ecosystems. In Minnesota, temperature is predicted to increase even more than the global average, which could result in the northward migration of boreal forests and a drying of Minnesota's wetlands. Many other impacts are postulated, but it is virtually certain that climate change will result in large adaptation costs, as entire economies and cultures must adapt to a new and changing environment.

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[8] Intergovernmental Panel on Climate Change, Working Group III, Climate Change 2000: Economic and Social Dimensions of Climate Change, Cambridge University Press: Cambridge, UK, 2001.

[9] The National Academy of Sciences review is in Appendix D of "U.S. Climate Action Report 2002", U.S. Department of State, Washington, D.C., 2002; available at: www.epa.gov/globalwarming/publications/car/index.html.

Calculating the Health Impacts of Coal Plants

This analysis looks at the health impacts of just one pollutant from the Riverside plant, particulate matter (PM). Therefore the total health and environmental impacts of the Riverside plant are greater than reported here.

Particulate Matter and human health

A large body of evidence exists for the link between PM and human health, going back to the early part of the 20th century. In December of 1952, stagnant meteorological conditions in London combined with high emissions of particulates from coal combustion to produce a public health crisis. Hospitals recorded 2,851 excess deaths within 5 days of the event and another 1,224 excess deaths in following weeks. Researchers did not need advanced methodologies to figure out that high concentrations of particulate air pollution cause severe health problems.[10]

Since then, sophisticated statistical methods have been used to precisely determine the relationship between PM and a wide range of human health impacts. Literally hundreds of such studies have been done, firmly establishing the link between PM and human health. Moreover, scientists have determined that that health impacts occur at levels of pollution that are well below current air quality standards. Many researchers have hypothesized that there is in fact no "threshold level" below which health effects do not occur.[11]

Overview of the model used to calculate health impacts

The model used here is a "meta-analysis"; that is, the calculations used for this report to estimate health impacts for the Riverside plant rely on the relationship between particulate matter and human health established in other studies. The process for estimating those impacts is shown in Figure 2 and outlined briefly in the text below.[12]

Emissions data for current emissions is reported by the utilities to the Minnesota Pollution Control Agency. Natural gas emissions are estimated data on existing plants, and may be slightly different than Xcel's emission projections for the converted plant.[13] It is also assumed for the purposes of this study that there will be no increase in capacity or utilization if the plant is converted to natural gas, which is not the case for Xcel's planned conversion – capacity will be increased about 20 percent. It is unclear if the utilization of the plant – currently at around 70 percent – will change.

[10] See Holgate, Steven, et. al., Air Pollution and Health, Academic Press: London, 1999.

[11] See for example, Daniels, J.J., et. al., "Estimating Particulate Matter Mortality Dose-Response Curves and Threshold Levels: An Analysis of Daily Time-Series for the 20 Largest US Cities," American Journal of Epidemiology, Vol. 152, No. 5, pp. 397-406, 2000.

[12] For a full discussion of the methodology, see the original report (footnote 4).

[13] Actual emissions rates are not available from information made public by Xcel, but the emissions numbers assumed here are expected to be close, or perhaps slightly above, those of the Xcel proposal.

Figure 2: Overview of Model and Major Data Inputs [14]

1. Calculate emissions from Riverside plant

⇒ Data from Minnesota Pollution Control Agency (MPCA) for PM_{10}, SO_2 and NO_X

2. Predict change in ground-level concentrations of pollution due to Riverside plant

⇒ U.S. Environmental Protection Agency (EPA) air quality models used to perform calculations

⇒ Stack height and other stack information from MPCA

⇒ Meteorological data from EPA

⇒ Location, elevation and population information of census tracts, block groups, counties, and states from Census Bureau and U.S. Geological Service.

3. Estimate health impacts of change in pollution levels on population

⇒ Scientific studies of the health impacts of particulate matter

4. Estimate economic value of health impacts

⇒ Existing literature on economic valuation, such as surveys to assess the value of a lost life and cost of illness studies

Once the dispersion of PM has been estimated, the effect on the population can be estimated. Existing scientific studies of the relationship between PM and a specific health impact are used. These studies are chosen for their reliability and acceptance within the scientific community.

In order to compare alternative policy scenarios for reducing power plant pollution, it is helpful to have an estimate of the costs to society from this pollution. This information will allow easier comparison of the economic benefits to society of reducing pollution with the economic costs of pollution control equipment. For that reason, the economic costs to society of the health impacts are calculated in this study. The values used for each of the impacts are based largely on EPA's review of the literature on economic valuation.[15]

Several recent studies have used a very similar methodology to the one used here to estimate damages of particulate matter from coal-fired power plants, including two conducted by the Harvard School of Public Health.[16] In June 2000 the Health Effects

[14] Derived from page 25 of the original report (cited in footnote 3).

[15] U.S. Environmental Protection Agency (EPA), "The Benefits and Costs of the Clean Air Act: 1990 to 2010," EPA-410-R-001, Washington, D.C., November, 1999.

[16] Jonathon Levy, et. al. "Development of a New Damage Function Model for Power Plants: Methodology and Applications," Environmental Science and Technology, Vol. 33, No. 24, pp. 4364-4372, 1999; and Jonathan Levy, et. al. "Estimated Public Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plants," Harvard School of Public Health, Boston, May, 2000. See also Jonathon Levy, "Modeling the benefits of power plant emission controls in Massachusetts," Journal of the Air and Waste Management Association, vol. 52, pp. 5-18, 2002; and Abt Associates Inc., "The particulate-

Institute, an independent organization jointly funded by industry the federal government, released a report that validates one of the major epidemiological studies used to predict health impacts in this study.[17]

In addition to calculating current damages from coal plants in a baseline scenario, hypothetical damages are calculated assuming the Riverside plant is converted from coal to a modern high-efficiency natural gas plant.

Uncertainty in the modeling

There is a great deal of uncertainty inherent in this type of modeling, due to uncertainty in each of the steps, and the number of steps involved in reaching the final results. For example, air quality modeling is generally considered accurate within a factor of 2 (from half the estimated value to double the estimated value). There is further uncertainty in the relationship between concentrations of PM and health impacts, based on scientific studies.

A study published in Science, with a similar methodology to this one, has a central estimate of 64,000 premature deaths that could be avoided in 4 large cities with reductions in particulate matter, but the 95 percent confidence interval for this central estimate is from 18,000 to 116,000 premature deaths.[18] In other words, the authors best guess as to the “true” number of premature deaths is 64,000, and they are 95 percent sure that the “true” number lies between 18,000 and 116,000 -- a fairly large range (28% to 180% of the central estimate). The results presented here are central estimates that can be expected to have a similar level of accuracy, and should be interpreted with caution.

Description of health impacts modeled

The model calculates eight different health impacts from PM, which are well documented in the scientific literature.[19] All of the impacts are expressed as annual impacts, and are due entirely to PM emissions of the Riverside Plant (both direct PM as well as indirect PM from NO_x and SO_2). The eight impacts are:

- **Premature mortality (death).**[20] There is a wide body of evidence for the association of mortality with changes in ambient levels of PM.[21] Evidence suggests that deaths attributable to PM may occur in individuals who are already

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related health benefits of reducing power plant emissions”, prepared for the Clean Air Task Force, Boston, MA, 2000 (available at www.cleartheair.org).

[17] Health Effects Institute, “Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality,” Cambridge, MA, July, 2000.

[18] Cifuentes et. al., “Hidden Health Benefits of Greenhouse Gas Mitigation,” Science, vol. 293, pg. 1257-1260, Aug. 17, 2001.

[19] For the rationale for choosing these particular impacts and the scientific literature used, refer to the full report (referenced in footnote 4).

[20] The original study broke down premature mortality into two age categories; 65 and older and 30 to 64. For simplicity, these categories are combined in this paper.

[21] The U.S. Environmental Protection Agency’s (EPA) Criteria Document for Particulate Matter provides an exhaustive review of mortality studies, supporting an association between PM and mortality rates: “Air Quality Criteria for Particulate Matter,” EPA/600/P-95/001, Washington D.C., April, 1996. EPA is in the process of updating this criteria document.

sensitive to cardiopulmonary symptoms. In many cases, PM can be considered a factor that aggravates pre-existing conditions, leading to premature death. Evidence also suggests that older populations are more susceptible to mortality impacts of PM. The study used here is the widely-cited American Cancer Society study that tracked 552,138 adults for seven years to establish the relationship between PM and premature mortality, since validated by the Health Effects Institute.[22]

- **Chronic bronchitis in adults.** Epidemiological evidence suggests an association between PM and chronic obstructive pulmonary disease (COPD), which includes emphysema, chronic bronchitis and asthma. For the study used to estimate this impact, a group of over 4,000 Seventh Day Adventists over age 25 were matched with 10 years of exposure to ambient pollutants.[23] This group was chosen because of their non-smoking behavior, which reduces the chance that their symptoms are due to other variables.
- **Childhood bronchitis.** Evidence shows that children are particularly susceptible to damage from PM. They tend to spend more time outdoors where PM levels are higher, and breathe heavily more often due to increased exercise rates. Impacts are calculated for children under 18 years of age.
- **Respiratory hospital admissions.** Elevated ambient PM levels can cause even people without chronic respiratory problems to go to the hospital for a variety of respiratory symptoms. Numerous studies have found an association between respiratory hospital admissions and PM.
- **Emergency room visits.** This estimates the number of emergency room visits that occur as a result of a range of symptoms due to PM emissions. These occur most frequently in vulnerable populations.
- **Asthma attack days.** The scientific literature suggests that people with asthma are particularly sensitive to increases in PM levels. This calculates the number of days that people with asthma suffer from an asthma attack due to increases in PM.
- **Restricted activity days.** Restricted activity days include days spent in bed, days missed from work and days when activities are partially restricted due to illness. This impact is calculated for the population over 18 years of age.
- **Respiratory symptom days (due to acute respiratory symptoms).** This health impact includes some days with symptoms bothersome enough to result in a restricted activity day, but also includes days when noticeable symptoms are present but no change in activities occurs.

[22] Pope, C. Arden, et. al., “Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults,” American Journal of Respiratory and Critical Care Medicine, Vol. 151, No. 3, pp. 669-674, 1995. For the HEI study, see footnote 14.

[23] Abbey, DE, F Petersen, PK Mills and WL Beeson, “Long-Term Ambient Concentrations of Total Suspended Particulates, Ozone and Sulfur Dioxide and Respiratory Symptoms in a Non-Smoking Population,” Archives of Environmental Health, 1993, Vol 48 (1), pp 33-46.

Results of the Study: Riverside's Current Health Impacts

Table 2 shows the annual estimated health impacts of the Riverside Plant from both direct and indirect particulate matter, for Minnesota and surrounding states. The model predicts that every year, air emissions from the Riverside plant are responsible for approximately:

- 8 premature deaths;
- 15 new cases of adult chronic bronchitis;
- 102 new cases of child acute bronchitis;
- 4 hospital admissions from respiratory causes;
- 84 emergency room visits;
- 1,180 asthma attack days;
- 17,100 restricted activity days; and
- 44,300 respiratory symptom days.

Table 2: Central Estimates of Annual Health Impacts from the Riverside Plant[24]

Health Impact	Units 6&7	Unit 8	Total[25]
Premature mortality (number of deaths)	2.2	6.4	8.6
Adult chronic bronchitis (new cases)	4	11	15
Child acute bronchitis (new cases)	26	76	102
Respiratory hospital admissions	1.1	3.4	4.5
Emergency room visits	21	62	84
Asthma attack days	301	878	1,180
Restricted activity days	4,370	12,700	17,100
Respiratory symptom days	11,300	33,000	44,300

Impacts were also calculated for just Hennepin County.[26] Table 3 reports the results of this analysis. Approximately one third of the total annual impacts occur in Hennepin County. The original report finds that about 60 percent of the total impacts occur within 30 kilometers of the plant (an area encompassing the 7-county metro area), 70 percent occur in Minnesota, and 30 percent occur outside of Minnesota.[27]

[24] Derived from page 48 of the original report (cited in footnote 3).
[25] Results have been rounded in some cases for clarity. In some cases this may result in the "Total" column having a different value than the sum of the individual units. Results in original report are reported to three significant digits.
[26] Gopalakrishnan Narayan at the City of Minneapolis Department of Health and Family Support performed the analysis, based on data provided by the author.
[27] Derived from page 52 of the original report (cited in footnote 4).

Table 3: Central Estimates of Annual Health Impacts Occurring in Hennepin County from the Riverside Plant

Health Impact	Units 6,7 & 8
Premature mortality (number of deaths)	2.7
Adult chronic bronchitis (new cases)	4
Child acute bronchitis (new cases)	48
Respiratory hospital admissions	1.4
Emergency room visits	29
Asthma attack days	302
Restricted activity days	5,250
Respiratory symptom days	20,200

The total annual economic value of these health impacts is estimated at $57.4 million.[28] This equates to approximately 2.8 cents in damages for every kilowatt-hour that is generated by the plant. For comparison, the operating costs of the Riverside plant are about 1.7 cents per kilowatt hour.[29] According to this study, the economic value of the public health damages exceeds the operating costs of the Riverside plant. Table 4 demonstrates that Riverside has the highest damages of any coal plant in the state, including three plants that have a greater electric capacity than the Riverside plant.

Table 4: Estimated Annual Damages from Other Minnesota Coal Plants[30]

Plant (with boiler numbers)	Size (megawatts)[31]	Total damages (millions of dollars)
Riverside (*6,7,8)*	351	57.4
Sherco (*1,2,3)*	2,257	47.5
Clay Boswell (*1,2,3,4)*	1,005	20.4
Allen S. King (*1)*	550	35.5
Black Dog (*3,4)*	277	9.2
High Bridge (*5,6)*	268	7.6
Hoot Lake (*2,3)*	143	2.4
Sly Laskin (*1,2)*	82	2.0
Silver Lake (*4)*	60	2.4

[28] About 88 percent of the total economic valuation of the damages comes from the valuation of premature mortality. This is due to the high value assigned by economists to the value of a statistical life, $5.76 million, taken from EPA's review of the economic valuation literature (footnote 12). Non-mortality impacts result in about $7.9 million per year in economic damages from the Riverside plant.
[29] Utility Data Institute, "1996 Production Costs of Operating Steam-Electric Plants," UDI-2011-97, Washington, D.C., September, 1997.
[30] Derived from page 52 of original report (cited in footnote 4).
[31] Summer operating capacity, based on utility-reported values to the U.S. Department of Energy.

Conversion to Natural Gas Would Improve Health

The model also calculated the hypothetical public health impact if the Riverside plant were converted to a Natural Gas Combined-Cycle (NGCC) plant. A combined-cycle plant can achieve thermal efficiencies of greater than 50 percent (compared to standard coal plant efficiencies of about 30 percent) by producing electricity through two processes. In the first cycle, natural gas is used to fuel an internal combustion engine, which drives a generator. Heat is then captured from this engine and used to drive a steam turbine in the second cycle. In 2001, a NGCC unit was installed at Xcel Energy's Black Dog coal plant in Burnsville, and is expected to be fully operational by the summer of 2002. For the scenario here, it was assumed that the same amount of electricity would be produced if Riverside converted to NGCC, even though Xcel Energy is planning on increasing capacity by about 20 percent when they convert the Riverside plant.

Table 4 reports the results of the modeling for the natural gas scenario. As a comparison with Table 2 shows, converting the Riverside plant to NGCC would reduce the health impacts by greater than 90 percent below current levels. Although health impacts to Hennepin county were not calculated for the natural gas scenario, they could also be expected to be only a fraction of the current impacts.[32]

The total annual economic costs of the health impacts for the NGCC scenario are $4.1 million. Put in another way, the conversion of the Riverside plant to natural gas would result in a public health benefit of about $53 million per year.

Table 5: Central Estimates of Annual Health Impacts for the Natural Gas Scenario at the Riverside Plant

Health Impact	Units 6&7	Unit 8	Total[25]
Premature mortality (number of deaths)	0.2	0.4	0.6
Adult chronic bronchitis (new cases)	0.4	0.7	1.1
Child acute bronchitis (new cases)	2	5	7
Respiratory hospital admissions	0.1	0.2	0.3
Emergency room visits	2.0	4.1	6.1
Asthma attack days	28	58	86
Restricted activity days	406	845	1,250
Respiratory symptom days	1,050	2,190	3,240

It should also be noted that converting to NGCC has other benefits. Emissions of nearly all pollutants of concern are significantly reduced. Mercury emissions, for example, would be virtually zero, and carbon dioxide emissions could be reduced by approximately two thirds. The elimination or reduction of these other harmful pollutants would result in additional, significant environmental benefits that are not included in the calculations in this paper.

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[32] Stack height for the natural gas scenario was assumed to be 40 meters – if the current stack for Riverside unit 8 were used (145 meters), this would reduce the impacts to Hennepin County from the natural gas scenario even further.