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Via Electronic Filing

March 1, 2013

Dr. Burl Haar
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101-2147

RE: In the Matter of Minnesota Power's Boswell Energy Center Unit 4 Environmental Retrofit Project
Minnesota Pollution Control Agency's Environmental Assessment
Docket No. E015/M-12-920

Dear Dr. Haar:

The Minnesota Pollution Control Agency (MPCA) hereby submits its environmental assessment of Minnesota Power's mercury emissions-reduction plan for Boswell Center Unit 4.

The report has been prepared to comply with the requirements of Minn. Stat. § 216B.684, which requires the MPCA to:

(1) assess whether the utility's plan meets the requirements of Minn. Stat. § 216B.682 or 216B.6851, as applicable,
(2) evaluate the environmental and public health benefits of each option proposed or considered by the utility, including benefits associated with reductions in pollutants other than mercury,
(3) assess the technical feasibility and cost-effectiveness of technologies proposed or considered by the utility for achieving mercury emissions reduction, and
(4) advise the commission of the appropriateness of the utility's plan.

Please contact Anne Jackson of my staff at 651-757-2460 with any questions.

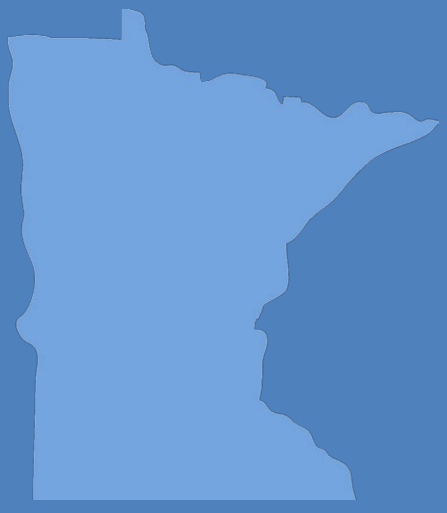
Sincerely,

Frank L. Kohlasch
Manager
Air Assessment Section
Environmental Analysis and Outcomes Division

FLK/AJ:jab

cc: David Moeller, Minnesota Power

Review of Minnesota Power's Boswell Unit 4 Environmental Improvement Plan



Minnesota Pollution Control Agency

March 1, 2013

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For more information

Contact any of the following MPCA staff members for more information about the preparation of this report, as well as other questions related to environmental controls for energy production.

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MPCA Review of Minnesota Power's Boswell Unit 4 Plan under the Mercury Emissions Reduction Act of 2006

1.0 Introduction

On September 4, 2012 Minnesota Power submitted an emission reduction proposal, the Boswell Unit 4 Environmental Improvement Plan, pursuant to Minn. Stat. §§ 216B.68 to 216B.688.[1] The proposal is to replace existing air pollution control equipment on Unit 4 of the Boswell station (the Boswell Unit 4) with a semi-dry scrubbing and fabric filter system designed to control mercury, sulfur dioxide(SO_2) and particulate matter emissions.

The proposed project will result in reductions of key pollutant emissions from the Boswell Unit 4 and the entire electric power generating station. Particulate matter (PM) will be greatly reduced, and mercury will potentially be reduced by greater than 90 percent from Unit 4. A modest additional control of SO_2 will also be realized.

Table 1. Summary of the Boswell Unit 4 and the Boswell station air emissions before and after proposed changes, tons per year

	Year	SO_2	PM	Mercury (pounds)
Boswell Unit 4 emissions	2011	1,061	1,275	233
Boswell Unit 4 emissions, retrofit		647	255	26
Boswell Unit 4 % reduction		**39%**	**80%**	**89%**
Boswell Station emissions, 2011		3,965	1,329	245
Boswell Station emissions, retrofit		3,551	309	39.6
Boswell Station % reductions		**10%**	**76%**	**83%**

In this report, the Minnesota Pollution Control Agency (MPCA) provides the analysis of Minnesota Power's proposal that is required under the Mercury Emissions Reduction Act, based on its expertise in evaluating pollution control projects as part of its long-standing air quality regulatory programs. Specifically, Minn. Stat. § 216B.684 requires the MPCA to advise the Minnesota Public Utilities Commission (PUC) as to the following:

- Assess whether the proposed mercury reduction project meets the requirements of section 216B.682 or 216B.6851, as applicable
- Evaluate the environmental and public health benefits of each option proposed or considered by the utility, including benefits associated with reductions in pollutants other than mercury
- Assess the technical feasibility and cost-effectiveness of technologies proposed or considered by the utility for achieving mercury emissions reduction
- Advise the PUC on the appropriateness of the plan.

[Minn. Stat. § 216B.684]

[1] The complete text of the statute is shown in Attachment 1.

The Mercury Emissions Reduction Act encourages a utility to submit mercury control plans that address controls of multiple pollutants (Minn. Stat. § 216B.684 (2), Minn. Stat. § 216B.686). Because Minnesota Power's project is a multi-pollutant control project, Minn. Stat. § 216B.686, subd. 3 instructs the MPCA to:

- Verify that the emissions reduction qualifies under MS § 216B.686, subd. 1, which requires that the utility filing demonstrate that:
  a. a project is needed to comply with state or federal control requirements that are effective after December 31, 2004
  b. that the plan provides increased environmental and public health benefits
  c. the plan does not impose excessive costs on the utility's customers
  d. will achieve at least the pollution control required by applicable state or federal statutes

The MPCA is also directed to:

- describe projected environmental benefits of the proposed project
- assess the appropriateness of the proposed plans

[Minn. Stat. § 216B.686, subd. 3]

Because it is the Minnesota Department of Commerce (DOC) and PUC's responsibility to determine whether a utility's rates are excessive or not as required by item b. above, the MPCA reviews capital and operating cost estimates to determine whether they are appropriately estimated, and requests that the DOC address questions of appropriate electricity rates to recover the cost of this project.

2.0 Summary of Findings

Does this multi-pollutant control project meet the requirements of 216B. 682 or 216B.6851, as applicable?

This project meets the requirements of Minn. Stat. § 216B.6851, addressing Minnesota Power's plan for controlling mercury emissions. This project will results in some reductions in sulfur dioxide (SO_2) and particulate matter (PM) and mercury will potentially be reduced by greater than 90 percent from Boswell Unit 4.

Minnesota Power elected to follow the process described in this statute in 2007 when it submitted its mercury reduction plan for Boswell Unit 3. Because of the superior mercury reductions at Boswell Unit 3 and the demonstrated ability of activated carbon injection to meet or exceed the 90 percent mercury reduction goal, however, Minnesota Power is not relying on supplemental mercury reductions achieved elsewhere to achieve the reduction goals at the Boswell Unit 4.

Evaluate environmental and public health benefits of each option proposed or considered by the utility:

The MPCA has undertaken a quantification of the benefits the multi-pollutant control project, that is, SO_2 and PM reductions, and an assessment of the benefits related to the reduction of mercury emissions.

The annual benefits of the Boswell Unit 4 plan range from about $15 million to $50 million. It is possible that there are non-quantifiable benefits, from other health impacts that were not part of the analysis and from welfare impacts such as ecosystem damage, visibility and materials damage, that would increase the actual benefits of this project beyond the estimates presented in this report. Given the current science for benefit valuation of pollution control, MPCA finds that for air pollutants subject to benefit valuation, the overall net social benefit of this project is negative since the total measurable costs exceed the total measurable benefits. Minnesota Power projects annualized costs of the Boswell Unit 4 plan to be nearly $66.8 million.

Annual benefits related to mercury reductions are not of similar confidence, due to continued uncertainty in important aspects important to benefit assessments. However, EPA and others regard IQ-related benefits as having the best support, and are estimated by the MPCA to range from $270,000 to $1.4 million per year for the Boswell Unit 4 project. Additional benefits related to avoidance of cardiac arrest are less certain and have a wide range in their annual benefit: $100,000 to $17 million per year. This quantitative benefit valuation also does not include social benefits received from the annual reduction of over 200 pounds of mercury emissions from the Boswell Unit 4.

There are additional unquantified avoided costs with this project: the project's elimination of a wet flue gas desulfurization system will significantly reduce expected future compliance costs related to federal regulations of coal combustion residuals. Additionally, the project's use of a semi-dry scrubber results in more energy-efficient equipment at the Boswell Unit 4, improving overall unit electricity generation efficiency.

Assess the technical feasibility and cost-effectiveness of technologies proposed for achieving mercury emissions reductions

Minnesota Power is using activated carbon injection to control mercury emissions from the Boswell Unit 4. This is the industry standard for control mercury from coal-fired boilers. The cost-effectiveness analysis evaluated types and quantities of carbon, and concludes that Minnesota Power's plan to use halogenated carbon to control mercury to achieve 90 percent control is cost-effective.

Advise the Commission of the appropriateness of the utility's plan

The Boswell Unit 4 has been well-controlled since initial operation because of its initial permitting under New Source Review program of the Clean Air Act. Sulfur dioxide reductions with the project are smaller than Minnesota Power's previous project under Minn. Stat. § 216B.6851 because of the current presence of good SO_2 controls. The Boswell Unit 4 current air pollution control devices cannot meet the federal Mercury and Air Toxics Standard (MATS) emission limits for mercury or particulate matter capture. In addition, the options evaluated by Minnesota Power show that Minnesota Power has selected a multi-pollutant control strategy that will achieve emission levels of SO_2 and particulate matter that are well beyond federal standards control requirements.

Minnesota Power described its planned construction schedule for this project as requiring more than four years from conceptual engineering to final plant startup, noting that for a project of this size, an extension of the compliance date under the federal MATS rule will be necessary. The MPCA has granted Minnesota Power its request of allowing an additional year in order to complete its ongoing compliance activities, thus establishing a compliance deadline of April 15, 2016 with the MATS rule.

Order of Document

In order to address each requirement of the Mercury Emissions Reduction Act, this document first discusses the technical feasibility of the mercury reduction plan for the Boswell Unit 4 and its cost-effectiveness. Next, the cost estimates of the project are reviewed. Thirdly, the MPCA discusses the environmental and health benefits, using a United States Environmental Protection Agency (EPA) model to calculate health benefits. Lastly, the appropriateness of Minnesota Power's project is discussed.

3.0 Technical Assessment of Minnesota Power's Reduction Plan

Minnesota Power has submitted a plan under Minnesota Stat. § 216B.6851 to control mercury emissions. The project is also a multi-pollutant control project to control particulate matter (PM) and sulfur dioxide (SO_2) from Boswell Energy Center Unit 4.

Minnesota Power's Boswell station has four operating electricity generating units. Unit 4 is a 585 MW pulverized-coal unit burning Powder River Basin subbituminous coal. Unit 4 commenced construction in 1978 and began operation in 1980. The unit is subject to U.S. Environmental Protection Agency (EPA's) New Source Review rules and thus was issued a construction permit that required to install best available control technology (BACT) to control particulate matter, nitrogen oxides and sulfur dioxides. The existing wet particulate matter scrubber and flue gas desulfurization controls continue to provide good control of particulate matter and SO_2 even as emission limits for coal fired electric generating units have become considerably more stringent.

Current Emission Profile

Minnesota Power has undertaken work to reduce air emissions from all four coal-fired boilers at the Boswell generating station, beginning in 2007 with an air emissions reduction project on the Boswell Unit 3. The installation of a fabric filter, selective catalytic reduction (SCR) equipment and flue gas desulfurization equipment was approved under Minn. Stat. § 216B.6851 in 2007 by the Minnesota Public Utilities Commission.[2] Emissions of sulfur dioxides, nitrogen dioxide, PM and mercury have been reduced substantially as a result of the pollution control project. Figures 1, 2 and 3 below demonstrate the emissions reductions at the station as a result of all emission reduction projects.

In addition to Unit 3, the remaining units at Boswell have also undergone nitrogen oxides reduction projects. New burners within the boilers that produce less nitrogen oxides (NO_x)and selective non-catalytic reduction projects on Units 1, 2 and 4 have been installed. Combined with the SCR on Unit 3, NO_x emissions from the station have been reduced by about 70 percent. Emissions of NO_x have gone from a maximum in 2008 of 15,463 tons to the current value of 4,715 tons in 2011. Figure 1 provides a graphical presentation of this information.

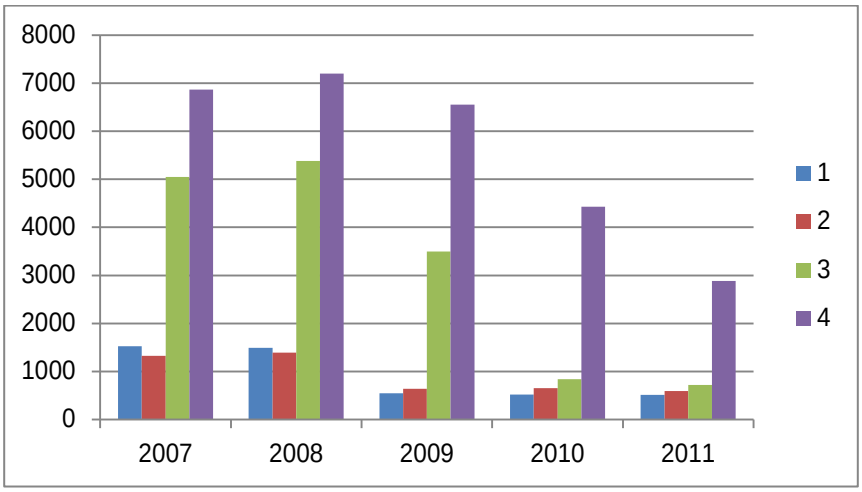


Figure 1. Nitrogen Oxides Emissions from Units 1 through 4 at Boswell Generating Station 2007-2011

[2] EQ15/M-06-1501, October 26, 2007. Minnesota Public Utilities Commission.

Sulfur dioxide emissions have also been dramatically reduced at the generating station as well. Figure 2 shows the emissions of SO_2 from each unit for the years 2007 to 2011. In combination with the startup of flue gas desulfurization controls on Unit 3 in 2009 and the selection of low sulfur coal beginning in 2010, SO_2 emissions have been reduced from a peak emission of 21,579 tons emitted in 2007 to 3,965 tons emitted in 2011, an 81 percent reduction over those five years.

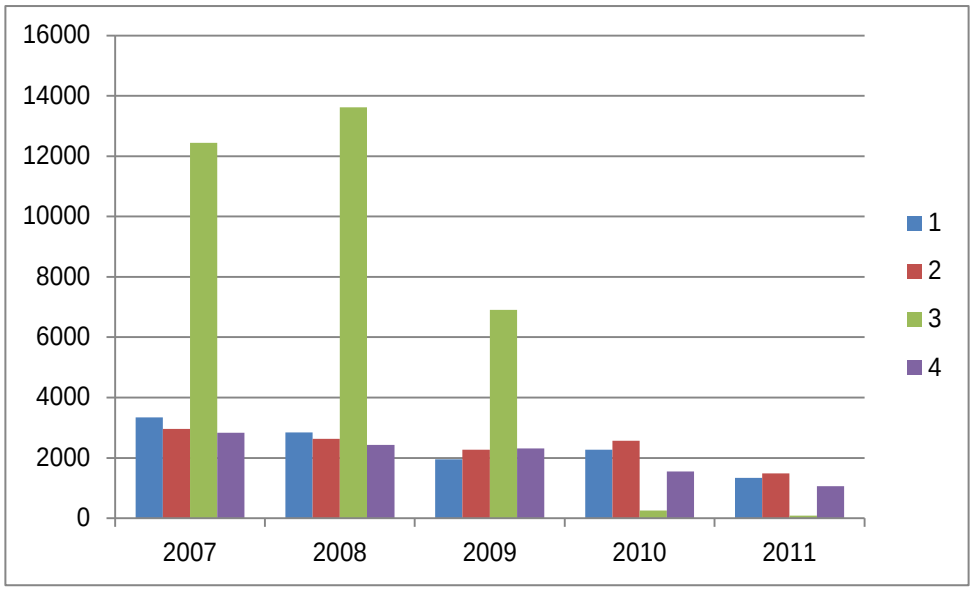


Figure 2. Sulfur Dioxide Emissions from Units 1 through 4 at Boswell Generating Station 2007 to 2011

Mercury emissions are also on the decline from this generating station. Figure 3 shows the mercury emissions from 2007 to 2011 by stack (Units 1 and 2 share a stack and are shown in blue). Units 1 and 2 have routinely demonstrated good control of mercury due to the high amount of unburned carbon in the fly ash. The use of a fabric filter for PM control and the "natural carbon" of the flay as provides inherent mercury control. The retrofit project at Unit 3 has been very successful in controlling mercury emissions, reducing mercury emissions from a high of 121 pounds to a low of about three pounds in 2011. Emissions at Unit 4 have increased due to higher amounts of coal being burned, and the fuel blend now being burned having a higher mercury content. Continuous mercury monitors were installed on Units 3 and 4 in 2007 in accordance with Mercury Emissions Reduction Act, and emissions data from 2008 onward is collected via the continuous monitors. Periodic stack testing will be used to measure mercury emission from units 1 and 2.

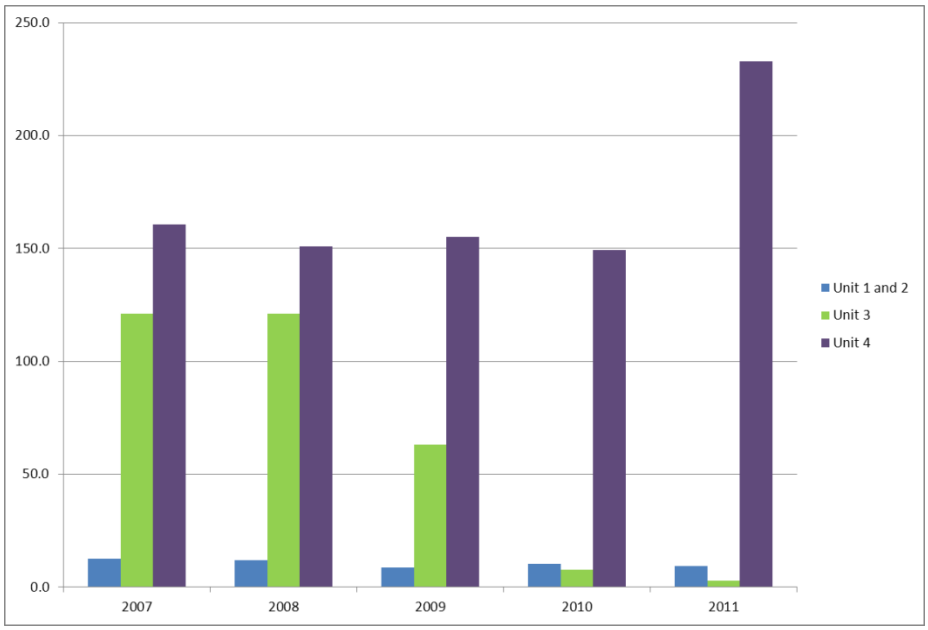


Figure 3. Mercury Emissions from Boswell Generating Station 2007 to 2011

Minnesota Power's Multi-Pollutant Control Plan

This emissions-reduction project encompasses reductions of a number of the primary pollutants of concern from power plant operations: PM, sulfur dioxides (as contributors to acid rain as well as precursors to fine PM), and emissions of toxic pollutants like hydrogen chloride and mercury, now regulated by EPA's Mercury and Air Toxics Standard (MATS) promulgated in February 2012. Unit 4 currently does not meet the PM or mercury emissions limit of the MATS rule. The PM limit is a surrogate pollutant measure for all non-volatile metals. The MATS rule also has an SO_2 limit, which is a surrogate limits for hydrogen chloride (HCl), the toxic acid gas being regulated by the standard.

Minnesota Power proposes to construct a circulating dry scrubber (CDS) and fabric filter. The CDS system is comprised of a vertical reactor tower, fly ash recirculation equipment and lime storage and handling. Ash is re-circulated from the fabric filter and mixed with lime and a small quantity of water in a mixer/hydrator. The ash and lime mixture is injected into the reactor tower where SO_2 and other acid gases are absorbed and react with the lime. The lime and ash and any reaction products are then transported by the flue gas into the fabric filter, where these solids are captured on the face of the fabric filter. This method of acid gas removal is referred to as "semi-dry"; water and lime are injected into the flue gas stream to remove SO_2, but rather than having water in the fly ash, it is evaporated in the flue gas. The resulting ash product is dry.

Table 2. Comparison of emission rates, including recent New Source Review limits, Mercury and Air Toxics Standards for utility boilers, and current and proposed emission rates for Minnesota Power Boswell Unit 4.

	Capacity		SO_2	PM	Mercury
	MW	*Mmbtu/hr*	*Lb/mmbtu*	*Lb/mmbtu*	*Lb/Tbtu*
The Boswell Unit 4, current performance (2011)	585	5615	0.049	0.06	5.28
BACT[3] (New Source Review)			0.060	0.011	0.015 lb/
Mercury and Air Toxic Standards (MATS), existing boilers			0.20	0.030	1.2
Emission rate, the Boswell Unit 4 Project			0.030	0.012	0.60
The Boswell Unit 4 current permitted emissions rate			0.33	0.10	NA

As shown in Table 2 above, proposed emission rate performance for this project reflect those rates being included in permits for construction of new coal-fired electric-generating units. Best available control technology is a case-by-case determination reflecting the best system of controlling emissions conducted during each new power boiler's review under the EPA's New Source Review program. Minnesota Power's proposed emission rates for this project meet BACT, and are considerably below existing permit limits for the Boswell Unit 4.

Fabric filters and semi-dry scrubbing for SO_2 control is well-developed technology in the power boiler industry. Minnesota Power reports in a reply to an MPCA request for information that certain components have already been purchased; Alstom Power's NID system has been selected to supply the semi-dry scrubber system.

The scrubber and fabric filter would be built alongside the existing wet venturi scrubber and spray tower absorber to allow continued operation of the generating unit during construction. Minnesota Power described its planned construction schedule for this project as requiring more than four years from conceptual engineering to final plant startup, noting that for a project of this size, an extension of the compliance date under the federal MATS rule is necessary. Minnesota Power has received an extension of the compliance deadline as provided for under state and federal rules from the MPCA.[4]

Assessment of State and Federal Emission Control Standards

Minnesota Power submitted filings in 2011 and 2012, as required by Minn. Stat. § 216B.6851, subd. 5 (b), describing the many federal environmental regulations promulgated or pending that address impacts from coal-fired power production. The air pollution rule of most consequence to the emission limits for the Boswell Unit 4 and the selection of control equipment is the MATS rule, adopted by EPA in February 2012. Other air quality rules, namely the rule to address regional haze[5] also require emission reductions, however, the stringency of the MATS rule limits will likely address any future SO_2 reduction requirements that might come from other rules. This project does not address any NO_x reductions that might be necessary under other program requirements.

[3] From US EPA's RACT/BACT/LAER Clearinghouse (http://cfpub.epa.gov/RBLC/). Emission limits for sub-bituminous coal-fired utility boilers from the past 5 years were selected.

[4] D Smith, MPCA. Approval of Request for One-Year Extension of Compliance Deadline for the Mercury and Air Toxics Standard at 40 CFR Pt. 63, Subp. UUUUU. January 28, 2013.

[5] Regional Haze Regulations (64 FR 35714, July 1, 1999)

Federal regulations for wastewater treatment at steam electric facilities and coal combustion residual standards for landfills accepting wet fly ash are likely in the near future[6]. The selection of a semi-dry SO_2 removal system eliminates wet fly ash and wastewater streams and their operational difficulties, and lessens future regulatory compliance requirements because of the elimination of wet fly ash handling for Unit 4. The change results in a dry ash, and eventual closure of the wet ash pond currently being operated to manage wastewater from the ash.

Assessment of Minnesota Power's mercury reduction plan

Minn. Stat. § 216B.6851 of the Mercury Emissions Reduction Act of 2006 allows a public utility with less than 200,000 customers subject to the conditions of Minn. Stat. § 216B.682 to elect to prepare and file a plan to reduce mercury emissions from targeted and supplemental units that is equivalent to a goal of 90 percent reduction, if the plan is filed by December 31, 2007. If the plan is not filed by this date, then the utility may only use emission reductions at targeted units to achieve the 90 percent reduction of mercury. Targeted units are those units greater than 100 MW located at power stations with generation greater than 500 MW.

Minnesota Power, as a public utility with less than 200,000 customers, first elected to pursue this option of complying with the Mercury Emissions Reduction Act when it filed its initial mercury reduction plan for Unit 3 in October 2006. Minnesota Power explained in the 2006 filing that it planned to use mercury reductions achieved at the Taconite Harbor generating station to supplement any potential shortfalls at Boswell should the projects fail to achieve the necessary reductions at the targeted unit. The Taconite Harbor project had been approved by the Minnesota Public Utilities Commission (PUC) prior to 2006. However, in this filing, Minnesota Power reports that the company will not be relying on emission reductions at supplemental units. Therefore, this project will be evaluated with the intention of achieving a 90 percent reduction of mercury at the Boswell Unit 4 specifically.

Technical Feasibility of Minnesota Power's Mercury Control Plan

EPA adopted the MATS rule for utility power boilers in February 2012. The standard is directed at controlling toxic metals and hydrogen chloride. To accomplish this control, most electric power boilers that do not already have acid gas scrubbing in place will likely install improved PM capture, for example fabric filters to better control metals and scrubbers to meet the acid gas control requirements. To achieve the mercury control established in the MATS rule, activated carbon injection (ACI) or selective catalytic reduction will be used at many utility boilers as a means of oxidizing elemental mercury so that it is captured as a particulate. [7] U.S. Energy Information Agency has begun the tracking of the installation of activated carbon injection systems, and reports that by the end of 2011, 258 generating units have installed ACI.

Minnesota Power described its process of evaluating mercury control options for Unit 4 in Exhibit 1 of the filing. Specifically, Alstom's Mer-cure and KNX process was identified as a mercury control technology that might be compatible with the continued use of the wet PM and scrubber system. Minnesota Power described the results of testing while burning differing fuel blends. The general result of the trials was that mercury control of 75 percent removal might be sustainable long-term, however the use of the technology interfered with compliance with opacity limits. Since completing the trial of this technology, the MATS rule has been promulgated. Mercury control greater than 75 percent will be

[6] US. EPA has proposed to revise the Steam Electric Effluent Limitations to address metals, nutrients and total dissolved solids in the wastewater discharges from coal ash storage ponds and flue gas desulfurization controls. Separately, EPA is considering regulating coal ash disposal facilities (Coal Combustion Residuals or CCR rules) in response to the failure of the TVA coal ash slurry pond near Knoxville Tennessee in 2008.

[7] U.S. EPA "Reducing Toxic Pollution from Power Plants Final Mercury and Air Toxics Standards (MATS)" December 2011. Web. Feb. 2013

necessary in order for Unit 4 to meet the mercury limit of the MATS rule making the Mer-cure and KNX technologies infeasible without better PM control to avoid the opacity problem.

With the proposal to add semi-dry scrubbing and a fabric filter, brominate activated carbon injection will be injected into the reactor tower to oxidize elemental mercury; the oxidized mercury is absorbed in carbon and captured as a particulate in the fabric filter. This proposal is likely to achieve 90 percent mercury reduction at the Boswell Unit 4 for a number of reasons. First, by replacing the existing air pollution control system, the existing scrubber bypass will be eliminated allowing the entire flue gas stream to be treated with carbon when it passes through the reactor tower fabric filter. Second, the installation of a fabric filter will allow ACI rates to control mercury emissions at removal efficiencies more likely to reach the statutory goal of 90 percent reduction in mercury emissions. Third, using brominated carbon is routinely demonstrating the ability to achieve emission reductions greater than 90 percent.

In Minnesota, ACI has been installed at Boswell Unit 3 and Xcel Energy's Sherco 3 and AS King. Because each facility must submit the results from the continuous mercury monitors, the MPCA has verified that each unit is demonstrating mercury control greater than 90 percent while using the brominated carbon. As shown in Figure 3 earlier, Boswell Unit 3 is controlling mercury emissions at reduction levels greater than 90 percent; similar levels have been demonstrated by Xcel at King and Sherco 3.

Continuous mercury monitors have been installed to collect mercury emissions data. Mercury monitoring was installed in July 2007 as required by Minn. Stat. § 216B.681 and the data has been used to estimate current emissions. Continuous monitors will be reinstalled to measure mercury emissions after retrofitting the new air pollution controls.

Cost effective analysis of Mercury Removal

The Mercury Emissions Reduction Act does not require achievement of 90 percent mercury removal, but rather requires equipment and operations that is "…most likely to result in the removal of at least 90 percent of the mercury emitted from the unit." Minn. Stat. § 216B.682, subd. 1 (b). The statute also asks the MPCA in its environmental review to assess the cost-effectiveness of the mercury control technologies evaluated. Because the Mercury Emissions Reduction Act does not define cost-efficiency, and the required mercury reduction is not fixed but a goal, the MPCA is choosing to define "cost effectiveness" as the least-cost alternative that comes closest to achieving the statute's stated goal of maximizing mercury removal, with "at least" 90 percent control.

The efficiency of mercury removal by ACI system depends on the type and amount of carbon injected. Carbon treated with a halogen ("halogenated carbon") is more effective in removing mercury, but more expensive to purchase. In order to assess the sensitivity of the cost-effectiveness to the amount of and type of carbon used in an ACI system, the MPCA requested that Minnesota Power provide the cost of operating the ACI system to achieve compliance with the MATS rule (which for Unit 4 is slightly less than an additional 80 percent reduction), a case where the ACI system is operated to obtain an 80 percent reduction of mercury, and finally, a case that achieves the statutory goal of 90 percent reduction.

A cost-effectiveness analysis of Minnesota Power's proposal for mercury control can be constructed as shown in the table below. The alternatives reflect the mercury removal efficiency needed in order to comply with the MATS limit of 1.2 lb/TBtu.

Table 3. Cost-Effectiveness of Potential Mercury Control Options at Minnesota Power the Boswell Unit 4 (Baseline year 2011)

	Proposed Project	Alternatives to Proposed Project	
	ACI w/halogenated carbon	*ACI w/non-halogenated carbon*	*ACI w/halogenated ACI*
% mercury control	90%	<80%	80%
Mercury emitted after project, lb/yr	26	51	47
Mercury reduction, lb/yr	207	182	186
Operating Cost of ACI system	$ 3,600,000	$ 4,200,000	$ 3,200,000
$/lb of mercury removed	$ 17,391	$ 23,076	$ 17,204
Carbon injection rate lb/mmacf	2.5	5	1.25

Other technologies are available, like Gore's mercury control system for coal fired boilers.[8] In this filing, Minnesota Power did not offer an assessment of potential technologies applicable to the coal fired unit other than activated carbon injection[9]. Given the interest in securing real reductions to comply with MATS, meet the statutory mercury reduction goal, the compatibility of ACI with semi-dry scrubbing and a fabric filter, and the demonstrated success of ACI at utility boilers[10] in Minnesota, the MPCA believes that activated carbon represents a responsible, cost-effective technology for controlling mercury emissions.

The cost-effectiveness calculation above demonstrates that the use of halogenated carbon is a cost-effective choice, as its mercury control effectiveness results in a higher removal rate than untreated carbon, and the higher amounts of mercury remove result in a lower cost per pound of mercury captured.

Table 4. Post-Project Annual emissions of mercury

Unit	Mercury 2011 (pounds)	Mercury post-project (pounds)
Boswell 1	3	unchanged
Boswell 2	3	unchanged
Boswell 3	6	unchanged
Boswell 4	233	26
Total Annual Emissions—Boswell Energy Center	245	39.6
Emissions change		-207 lbs
Percentage change at the Boswell Energy Center		-85%

[8] Gore. Mercury Control Systems for Coal Fired Applications. Web. February 2013.

[9] Minnesota Power described in the filing exhibits alternatives to mercury controls that included replacing the entire unit with natural gas-fired generation. The PUC has determined that Boswell 4 is XXXX.

[10] Minnesota Power describes the mercury reduction achievement in its October 2012 filing related to Boswell 3. Docket No. E015/M-06-1501. Minnesota Power submits quarterly reports to the MPCA of mercury emissions released as measured by the continuous mercury emissions monitor. The monitoring data demonstrates better than 90% removal of mercury.

4.0 Estimated Capital and Annual Cost of the Proposal

The MPCA reviewed the cost of the proposed project to determine whether the estimated cost is reasonable because the cost is compared with the estimated benefits of the project. Both annual and capital costs were reviewed to determine whether they are within an expected reasonable range for the size and nature of the project.

Assessment approach

In the filing, Minnesota Power provided a total project estimate for this project, and an annual levelized operating cost that includes capital recovery and ongoing operating and maintenance costs related to the multi-pollutant control project.

To assess the reasonableness of the overall capital cost estimate for the project, the MPCA identified air pollution control projects at similar sized-boilers. The cost per kilowatt of generation ($/kw) being controlled by the project was calculated as one measure of project cost.

The Mercury Emissions Reduction Act requires the MPCA to assess the cost-effectiveness of mercury controls but not for pollution control projects aimed at reducing other pollutants like particulate matter and SO_2. Therefore, we first simply describe the review of costs reported for this project to determine if they are reasonable estimates. In Section 3.0 of this report we separately examined the cost-effectiveness of mercury reduction, as required by Minn. Stat. § 216B.684, item (3).

Capital Cost

Minnesota Power reports that cost estimates were prepared on Minnesota Power's behalf by its engineering consultant. The cost estimates have been developed based on consulting engineers' like-kind project experience and vendor proposals, as well as Minnesota Power engineering resources and experience. Reported capital costs for pollution controls were based on competitive bids. Minnesota Power reports in a reply to an MPCA request for information that certain components have already been purchased; Alstom Power's NID system has been selected as the semi-dry control system. The largest single contract component is that of general construction.

Site Specific Factors

The MPCA asked Minnesota Power to provide additional information about the project costs because the capital cost of this project appears considerably greater than similar projects undertaken in Minnesota and elsewhere for projects with similar scope.

Minnesota Power responded by providing additional explanation about the scope of this project, and the nature of site-specific factors. Of largest consequence at Boswell is the limited space onsite to include new equipment. The space restrictions require relocating existing piping and electrical equipment and makes ductwork tie-in locations more difficult. Site preparation cost estimates include installing sheet pile walls and adding lake fill, while also providing a conservation easement of eight to ten acres of the existing site.

Converting to a dry ash management system requires the construction of a silo, all associated piping and blowers to convery the ash. The Boswell Energy Center is built adjacent to Blackwater Lake. Due to the lake, the ash silo has to be located on the other side, requiring additional piping and larger equipment to convey ash to the silo.

Table 6 at the end of this section compares the cost of the Boswell Unit 4 project to several air pollution control projects currently underway elsewhere. The scope of projects differs due to site conditions. Minnesota Power estimated the cost of the differing scope of the projects, reported in in the table as "differential scope" and the estimated capital cost as "differential $". The project for Minnesota Power is more costly than past projects; the scope of the project is smaller than that for Boswell Unit 3 or the Ottertail Power Big Stone retrofit (no NO_x) controls are required with this project for Unit 4).

Capital costs for scrubbing at power plants has been increasing. The Energy Information Agency reports the "average cost of existing flue gas desulfurization units" in its Electric Power Annual report[11]. The January 2013 EPA report shows the following trend:

Table 5. Average Costs of Existing Flue Gas Desulfurization Units, United States.

Year	Average Operation and Maintenance Costs (Mills per Kilowatthour)	Average Installed Capital Costs (Dollars per Kilowatt)	Installed Cost Percent Annual Increase (MPCA Calculation)
2007	1.51	135.41	
2008	1.55	150.77	11
2009	1.61	186.73	10
2010	1.61	206.27	24
2011	1.94	240.34	17

Installed costs are described as including all major modifications related to emissions control. Owners are asked to report costs for structures and equipment, sludge transport and disposal, and the installed cost of flue gas desulfurization. Land is not included in the reported project costs.

Summary

Construction (and operating) cost estimates for the Boswell Unit 4 project prepared by Minnesota Power and their consultant appear to be reasonable estimates for this project. Estimates were generated using reliable data sources and standard estimating procedures and tools. The estimates take into account potential site limitations. The MPCA believes that Minnesota Power has used best available information to estimate capital and operating costs of these pollution control projects and at this time are appropriate estimates of the project.

[11] U.S. Energy Information Administration Electric Power Annual. Scrubber costs are reported to EIA by electricity generators in their annual reports to EIA (Form EIA-860, "Annual Electric Generator Report"). Web.

Table 6. Comparison of the the Boswell Unit 4 air pollution control device capital costs

Project	Company	Total Reported $ (million)	MW (net)	Differential Scope	Differential $ (million)	Comparable $ (million)	Escalation	In service year	$/kW	
Big Stone	Otter Tail Power Co	$491	475	Eliminate SCR	$190	$301	0	2016	$640	a
Flint Creek	SWEPCO	$408	508	Eliminate Low NO_x burners	$15	$393	0	2016	$744	b
Boswell 4	MP	$431	585				0	2015	$737	c
Boswell 4	MP	$431	585	Eliminate byproduct Ash handling system	$66	$365	0	2015	$624	d
Boswell 3	MP	$240	352	Eliminate SCR	$73	$167	3.0%		$$583	e

a. Big Stone cost estimate from January 2013 Otter Tail Power Company quarterly filing during construction. The selective catalytic reduction system (SCR) is required for NO_x control, so is removed from the project costs to align the scope of the project with the Boswell Unit 4 project.
b. Flint Creek Estimate from public FAQ website for the project. Flint Creek is installing the same semi-dry and fabric filter system as the Boswell Unit 4. Minnesota Power estimated Lo NO_x burners and overfire air construction costs and eliminated them from this project.
c. BEC4 –The Boswell Unit 4 retrofit project as proposed in the filing.
d. BEC4—The Boswell Unit 4 retrofit project with the fly ash handling equipment separated. The scope of the Flint Creek project likely does not includes the same type of ash handling modifications as the Boswell Unit 4 as Flint Creek already has dry ash handling equipment in place. Because the Boswell Unit 4 is moving from a wet ash handling system to generating dry ash, equipment needs to be installed to store, manage and landfill additional fly ash quantities once the Boswell Unit 4 starts generating dry fly ash. Ash handling equipment also reflects existing site conditions that require additional equipment and site preparation.
e. BEC3 the Boswell Unit 3 project included an SCR and ammonia handling. Also, 2009 costs are escalated to an in-service date of 2016.

5.0 Assessment of Benefits of the multi-pollutant reduction plan

The MPCA is directed to evaluate environmental and public health benefits from the implementation of a mercury-control project; when multi-pollutant projects are proposed, the MPCA is also directed to describe the benefits of implementing that plan [Minn. Stat. §§ 216B.684 (2) and 216B.686, subd. 3 (1) and (2)].

Electrical utility power plant emissions contribute to air pollution in a multitude of ways. In Minnesota, power plants are major contributors to the emissions of sulfur dioxid (SO_2), nitrogen oxides (NO_x), carbon dioxide, mercury and other metals. Power plant emissions of NO_x contribute to ozone pollution. Emissions of SO_2 and NO_x contribute to fine particulate formation, visibility impairment in natural areas, and acid rain. Mercury emissions contribute to fish consumption advisories and water quality impairment via atmospheric deposition on lakes, rivers and contributing watersheds.

Assessing the benefits of any emissions reduction plan requires a multistep process that answers the following four questions:

- What is the change in pollution level as a result of the plan?
- Who is exposed, or what is the difference in exposure to pollution for all affected people as a result of the plan?
- What are the changes of health and welfare impacts as a result of the change in pollution exposure?
- What are the economic values of these impacts?

MPCA has completed modeling and analysis to systematically address the four questions above for the Boswell Energy Center Unit 4 pollution reduction plan. This chapter of the report addresses each of the above questions and ultimately arrives at estimates of the economic values of the benefits from the Boswell Unit 4's multi-pollutant reduction plan. However, due to limitations in benefit valuation, only the economic values of the benefits of SO_2 and Particulate matter (PM) are quantitatively estimated. For other pollutants, including mercury, a qualitative review of potential benefit valuation is provided.

Multi-pollutant Control Public Health and Environmental Benefit Estimate

The most significant pollution impacts of electrical power plant emissions are impacts to human health. Thus, benefits assessment of emissions reductions is primarily focused on human health benefits assessment. Other human *welfare* impacts of power plant emissions which do not directly relate to human health, such as visibility impacts, materials damage and ecosystem damages, are less significant and cannot be reasonably quantified or valued in monetary terms using currently available models.

To assess the benefits of pollutant reduction by systematically answer each of the four questions posed above, MPCA used a benefit estimating model developed by the US Environmental Protection Agency (EPA) known as the Environmental Benefits Mapping and Analysis Program (BenMAP)[12]. BenMAP uses a "damage-function" approach to estimate the health benefits of a change in air quality[13]. It comprises a multi-step modeling process that estimates the health impacts and economic benefits occurring when

[12] http://www.epa.gov/air/benmap/

[13] A "damage function" approach uses air quality models to estimate changes in pollutant concentrations, health effects information from epidemiology studies or other relevant findings to estimate the reduction in adverse impacts (e.g., health effects in human populations) per unit reduction in air pollutant concentration for the population in the study domain, and assigns monetarily values to the change in impacts.

populations experience changes in air quality. BenMAP is the state of the art tool that EPA and other agencies use to assess the health impacts and economic values for changes in air quality and EPA regularly uses these methods in the regulatory and policy analyses for major air pollution programs. The MPCA prefers the BenMAP model because it (a) can be configured to fit local conditions, (b) rests on foundation materials written since studies that supported the Commission's externality values were written, and (c) follows EPA's methods for $PM_{2.5}$ health benefits assessments. The method BenMAP uses to estimate health impact incidence and valuation has been reviewed by the National Research Council (for $PM_{2.5}$)[14] and BenMAP itself has been peer-reviewed by a review panel assembled by EPA.[15] Appendix A contains a detailed explanation of how BenMAP was used to estimate the health benefits from pollutant reductions at the Boswell Unit 4.

What is the change in pollution level as a result of the Boswell Unit 4 plan?

Answering this first question of benefits assessment requires air quality and air dispersion modeling to translate emissions reductions to changes in ambient air quality. (Note: changes in pollution levels for other media, notably water, as a result of the Boswell Unit 4's emissions reductions are not likely to be significant and are thus not considered in this analysis.) The emissions reductions as a result of the Boswell Unit 4 Plan are drawn from Minnesota Power's petition to the State of Minnesota. Table 7 below shows annual emissions from the Boswell Unit 4 before and after implementation of the multi-pollutant reduction plan, as projected by Minnesota Power. Baseline emissions (before implementation of the plan) are derived from the MPCA Annual Emissions Inventory for 2011, representing typical operation at the Boswell Unit 4. The emission reduction projections are from Minnesota Power's petition to the MPCA for the proposed changes.

Table 7. Annual emissions for Minnesota Power Boswell Energy Center Unit 4 Based on 2011 emissions levels)

	SO_2 (tons/year)	PM (tons/year)	Mercury (lbs/year)
Baseline, prior to plan implementation	1,061	1,275	228
After implementation of plan	647	259	26
Emissions decrease	414	1,016	202
Percentage change	-39%	-80%	-89%

The table shows that as a result of the multi-pollutant reduction plan, the Boswell Unit 4 plant will have greatly reduced emissions of mercury, $SO_2$and particulate matter. It should be noted that there are no projected reductions in nitrogen oxides (NO_x). This is largely due to the fact that prior to implementation in this plan, the Boswell Unit 4 completed a retrofit in 2010 in which control equipment was installed that produced a better than 50 percent reduction in NO_x emissions. As a result of this retrofit, annual emissions of NO_x were reduced from approximately 7,000 tons to under 3,000 tons. This reduction produced significant human health benefits. These benefits, however, are not factored into our analysis due to the fact that they were completed before the current multi-pollutant reduction plan being

[14] National Research Council (NRC), Estimating the Public Health Benefits of Proposed Air Pollution Regulations, 2002, National Research Council. The National Academies Press, Washington, D.C., www.nap.edu/catalog.php?record_id=10511.
[15] Van Houtven, George. Peer Review of BenMAP Software Peer Review Report. RTI International, Research Triangle Park, N.C. March 2004.

evaluated here. Had these benefits been included, the total value of benefits of the Boswell Unit 4's pollution reduction plan would be higher.

MPCA utilized photochemical air quality modeling to translate these changes in emissions for SO_2 and PM to predicted changes in ambient concentrations of health-impacting pollutants. Of greatest concern is the health effects associated with the contribution of power plant emissions to the amount of fine particulate matter ($PM_{2.5}$) found in the air. Fine particles can be directly emitted, but many, if not most, are formed in the air from chemical reactions of nitrogen oxides, sulfur oxides, organic compounds, and ammonia. Power plant emissions contribute to local and regional levels of $PM_{2.5}$. Fine particles are associated with a range of adverse health effects, such as coughing, phlegm, shortness of breath, acute and chronic bronchitis, asthma symptoms, increased susceptibility to respiratory infections, reduced lung function, heart attacks, and increased risk of death from cardiovascular and respiratory conditions. EPA's concern about the health effects of fine particulates has resulted in its recent tightening of air-quality standards for $PM_{2.5}$ and SO_2. Minnesota experiences degraded air quality due to fine particulate matter.

MPCA's photochemical modeling was used to predict ambient $PM_{2.5}$ concentrations from Minnesota emission sources both before (baseline level) and after (control level) the implementation of the Boswell Unit 4 multi-pollutant reduction plan from changes in emission rates of SO_2 and PM at Boswell Energy Center Unit 4. Comparison of the baseline and control ambient air quality levels is the answer to the first question posed above: *What is the change in pollution as a result of the plan?* Figure 1 below shows how the Boswell Unit 4 project is expected to change fine particulate matter concentrations. Changes are recorded in terms of micrograms per cubic meter ($\mu g/m^3$). Areas of greatest decrease in $PM_{2.5}$ are in dark blue, just around the plant. Note that the areas closest to the Boswell plant experience the greatest air quality improvement.

Annual Average $PM_{2.5}$ Difference

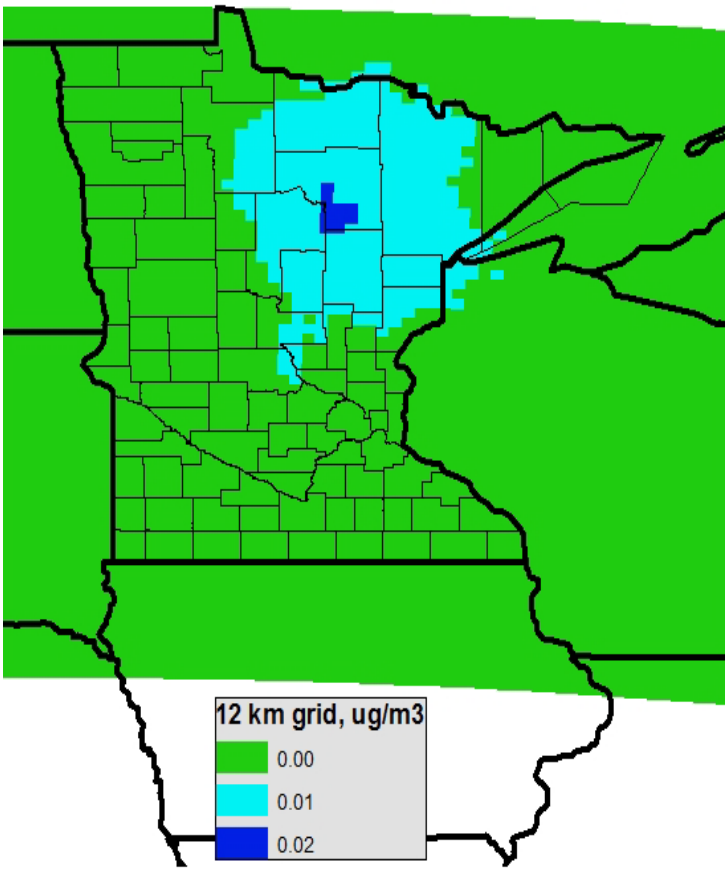


Figure 4. Selected area for BenMAP benefits calculation and change in $PM_{2.5}$ concentrations modeled due to the SO_2, NO_x and direct $PM_{2.5}$ emission controls at Boswell Energy Center Unit 4

What is the difference in exposure to pollution for all affected people as a result of the Boswell Unit 4 plan?

The analysis of the Boswell Unit 4 plan that MPCA conducted with BenMAP used 2010 U.S. census data to determine the change in $PM_{2.5}$ pollution exposure (i.e., the difference between baseline and control levels) for all persons in the region affected by the Boswell Unit 4 plan. The 2010 U.S. census not only provides the most up-to-date data on the distribution of population throughout the region, but also provides demographic data of more vulnerable populations, such as the elderly and young children, who are generally more susceptible to the health impacts of air pollution and thus stand to most benefit from air quality improvements.

What are the changes in health impacts as a result of the Boswell Unit 4 plan?

The primary health impacts of $PM_{2.5}$ pollution, based on the most up-to-date and credible toxicological and epidemiological literature are:

- Premature mortality
- Non-fatal heart attacks
- Hospital admissions for cardiovascular problems

- Hospital admissions for respiratory problems
- Emergency room visits for respiratory problems
- Acute bronchitis
- Lower respiratory symptoms
- Upper respiratory symptoms
- Asthma exacerbation
- Work loss days
- Acute respiratory symptoms

This list comprises all the human health outcomes that the EPA currently recommends for assessing the health impacts of exposure to $PM_{2.5}$ pollution. While this is not an exhaustive list of all the health impacts of $PM_{2.5}$ pollution, it does comprise the most significant impacts and those that can be reasonably quantified with the available epidemiological impact models and economic valuation models for addressing air pollution. This list could alternatively be represented as a pyramid, as shown in Figure 5.

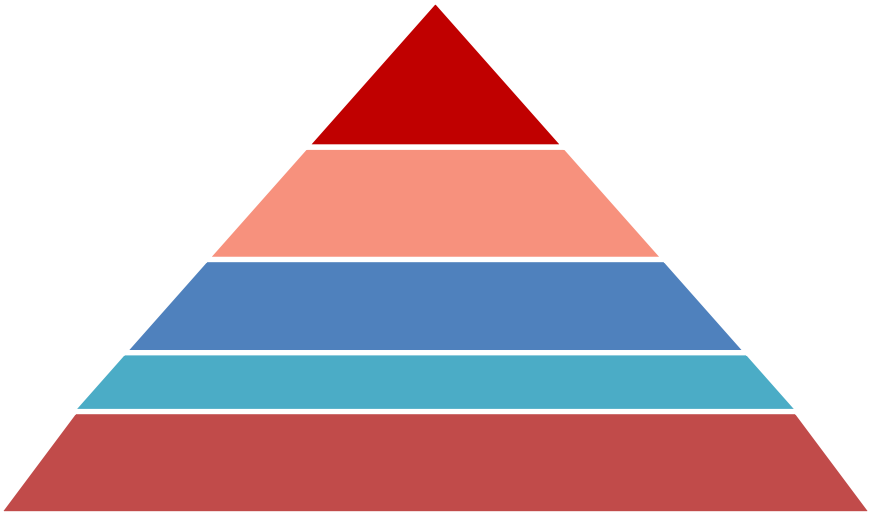


Figure 5. Pyramid of $PM_{2.5}$ health effects

Located at the top of the pyramid, the most significant impact, premature death, affects the fewest number of people. Moving down the pyramid the impacts are less and less severe but happen more frequently and affect more people.

BenMAP uses health impact functions to predict changes in health impacts as a result of changes in ambient air pollution. These health impact functions have been derived from the most highly-regarded and peer-reviewed epidemiological literature. Appendix A contains a more detailed explanation of how these health impact functions were selected and applied, as well as detailed explanations of the other elements of benefits estimation executed by BenMAP to estimate the health benefits from pollutant reductions at the Boswell Unit 4.

Table 8 shows the annual estimated benefits of reduced adverse health impacts from exposure to $PM_{2.5}$ pollution resulting from the Boswell Unit 4's multi-pollutant reduction project.

Table 8. Estimate of the annual reduction in $PM_{2.5}$-related health outcomes from Boswell Energy Center Unit 4 Multi-pollutant Reduction Plan

Health effect	Annual Reduction in Deaths and Illness		
	Minnesota	Modeled portions of adjacent states*	Total**
Mortality			
(low estimate)	1	1	2
(high estimate)	2	1	4
Nonfatal heart attack	1	1	2
Hospital admissions, cardiovascular	0	0	0
Hospital admissions, respiratory	0	0	0
Emergency room visits, respiratory	0	0	1
Acute bronchitis	2	1	2
Lower respiratory symptoms	19	12	32
Upper respiratory symptoms	28	18	45
Asthma exacerbation	28	18	47
Work loss days	125	78	203
Acute respiratory symptoms	740	468	1,208

* The region covered in this assessment includes portions of the neighboring states

** Due to rounding, totals may not agree with the sum of subtotals.

The results of Table 8 reflect the pyramid of health effects. The most severe impacts (premature death, heart attacks, hospital admissions) affect the fewest number of people and thus will see the fewest benefits in reduced health impacts. As will be explained below, however, even though these severe impacts see the fewest incidences, their economic values are extremely high relative to the less severe, but far more prevalent impacts. The estimates in Table 2 are pooled across the whole affected population, across demographic groups and across the entire affected region.

All phases of benefits estimation from pollution improvements involve uncertainty. One example of this uncertainty is the health impact function used to estimate premature mortality impacts. EPA currently recommends two different studies as highly credible estimators of the health impacts of $PM_{2.5}$ pollution. Applying one study produces an estimate of two[16] premature deaths per year, while the other health impact function produces an estimate of nearly twice as many premature deaths per year.

Even beyond the two estimates of mortality incidence presented in this analysis, epidemiological studies show a range of mortality estimates. Because a large portion of the estimated benefits are based on reduced mortality, the MPCA conducted a sensitivity analysis to determine the influence of the Concentration-Response function on the estimate of health impacts and related benefits. The MPCA

[16] Rounded to the nearest integer.

"high" estimate of mortality in Table 2 above comes from the epidemiological study by Daniel Krewski and colleagues, *The Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality*[17]. Since its publication, the EPA has recommended the Krewski et al study as the most credible estimates of premature mortality impacts from particulate matter pollution. These estimates have also been very broadly cited and have been recommended by EPA to be the most appropriate for the Upper Midwest. EPA's preeminent expert in assessing risks and benefits of air pollution has advised that this is currently the single best model to estimate the premature mortality impacts of $PM_{2.5}$ pollution and is also the most appropriate for the local conditions in the Upper Midwest.[18]

The "low" estimate for mortality comes from a recent study by Johanna Lepeule and colleagues, *Chronic Exposure to Fine Particles and Mortality: An Extended Follow-up of the Harvard Six Cities Study from 1974 to 2009*[19]. Although this study has been very recently published, the EPA also recommends it as providing highly credible (along with the Krewski et al study) estimates of mortality health outcomes caused by $PM_{2.5}$ pollution. The two epidemiological studies that each of these two studies draw upon, the American Cancer Society Study and the Harvard Six Cities Study are considered by the US Environmental (EPA) (and others) to be the most seminal long-term studies that have examined the relationships between $PM_{2.5}$ exposure and premature mortality. The selection of these two different concentration-response functions yield estimates of between 2 and 4 deaths avoided each year as a result of the Boswell Unit 4 project. MPCA provides both these estimates to frame a range of what the likely benefits of reduced mortality from $PM_{2.5}$ exposure resulting from the Boswell Unit 4's plan.

There are other uncertainties in the BenMAP model that have conservative or liberalizing influences on model results. A discussion of these influences, some of which could have been calculated, is included in Attachment 1 to this report.

What are the economic values of the health benefits of the Boswell Unit 4 plan?

Benefit estimates derive from economic valuation functions that place a value on health effects. Various studies are used to estimate these values. Two predominant types of economic valuation functions are cost-of-illness functions and willingness-to-pay functions. Cost-of-illness functions generally just consider the monetary cost to resolve an illness, including any lost earnings that result from sustaining the illness, but do not attempt to place a value on the pain and suffering associated with the illness. Cost-of-illness functions are generally applied to value the less severe (but far more prevalent) health impacts. Willingness-to-pay studies, on the other hand, attempt to capture the complete value of avoiding a health income; they do not represent just the financial cost, but rather reflect how much people value avoiding a health outcome. Willingness-to-pay studies are based on two sources: (1) surveys that ask directly what people are willing to pay to reduce the incidence of a specified health effect and (2) studies that compare the relative risks and wages of different jobs. Willingness-to-pay studies are generally applied to more severe health outcomes, notably premature mortality.

Using EPA's currently recommended economic valuation functions for valuing the health benefits of $PM_{2.5}$ pollution reductions, the total annual value of the Boswell Unit 4 health benefits from reductions

[17] Krewski, Daniel et al. 2009. *Extended Follow-Up an Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality*. Health Effects Institute, Number 140.

[18] Personal communication with Neal Fann, U.S. EPA Risks and Benefits Group Policy Analyst, January 9, 2013.

[19] Lepeule, Johanna et al. 2012. *Chronic Exposure to Fine Particles and Mortality: An Extended Follow-up of the Harvard Six Cities Study from 1974 to 2009.* Environmental Health Perspecitves 120 (7): 965-970.

of $PM_{2.5}$ pollution are in the range of $14 million to $31 million, depending on whether the low or high health impact function is used to estimate incidence of premature mortality. Mortality-related benefits have a dominant influence on benefit estimates and represent the lion's share of benefits of the Boswell Unit 4 plan. The estimated value of an avoided death, alternatively termed the value of a statistical life (VSL) currently used by EPA is $8.9 million. This estimate is based on a distribution fitted to 26 published VSL estimates that appear in the economics literature and have been identified in EPA's Section 812 Reports to Congress as "applicable to policy analysis." The mean of a distribution fitted to the estimates from these 26 studies is $7.9 million (in 2008 dollars). This is the figure that EPA currently recommends as a default VSL to value reduced mortality for all current programs and policies. For programs and policies that are projected to occur in the future, EPA modifies this estimate to account for rising incomes. (When people have higher incomes they are willing to pay more for reducing risk to a negative health outcome.) EPA's current default reference year for a change that will happen in the future is 2020. Thus, for this analysis, MPCA chose data for health incidence as well as willingness to pay based on projected income levels for 2020. The EPA recommended VSL based on 2020 incidence and income levels is $8.9 million. This is the value that MPCA chose for the value of an avoided death in assessing the benefits of the Boswell Unit 4 project.

MPCA will not go into great detail on the current values for non-mortality health outcomes in this report. In summary, all calculations to derive economic values of the improved health outcomes resulting from the Boswell Unit 4's plan relied on economic valuation data from EPA that is currently embedded in the BenMAP modeling framework.

Table 9 below shows MPCA's findings in more detail. The table shows that a majoring of the estimated benefits (57.5 percent) occur in Minnesota, while the remainder occur in neighboring states. (See Figure 4 for a depiction of the entire region impacted by the Boswell Unit 4 plan, which includes portions of Wisconsin, Iowa, North Dakota, South Dakota, Illinois, Michigan and Nebraska.)

Table 9. Estimated value of benefits from reductions in SO2 and $PM_{2.5}$ at Boswell Energy Center Unit 4

Health effect	Estimated value of benefits ($ thousands)		
	Minnesota	All other states	Total*
Mortality			
(low estimate)	$7,928	$5,866	$13,771
(high estimate)	$17,914	$13,252	$31,166
Non-fatal Heart Attacks	$93	$73	$167
Acute Respiratory Symptoms	$47	$30	$76
All other health effects**	$36	$24	$60
Sum, with the low mortality estimate	$8,104	$5,992	$14,096
Sum, with the high mortality estimate	$18,090	$13,378	$31,469
Sum, benefits not related to mortality	$176	$126	$302

* Due to rounding, totals may not agree with the sum of subtotals.

** Health effects with estimate values below $100,000 are hospital admissions for cardiovascular and respiratory problems, emergency room visits for asthma, acute bronchitis, respiratory symptoms (both upper and lower), days-of-work-lost, and exacerbation of asthma.

Discussion of mercury-related benefits

The vast majority of health benefits that the Boswell Unit 4 plan will produce are related to improvements in $PM_{2.5}$ air quality, as enumerated above. These benefits result from reduced emissions of PM and SO_2 from the Boswell Unit 4 plant, but are not at all impacted by the projected reductions in mercury emissions. It is harder to quantify and assign values to the health and environmental benefits of reduced mercury pollution given currently available methods. However, the value of reducing mercury pollution is not incidental. Following is a discussion of these benefits based on the current state of the science of the impacts of mercury pollution.

Power plant mercury emissions play a role in the accumulation of mercury in fish tissue, necessitating fish consumption advisories for water bodies. The MPCA's 2012 draft impaired waters list identifies 3,638 impaired waterways[20] in Minnesota are considered to be impaired because the fish in them are contaminated with mercury. Consumption of mercury represents potential decreases in IQ in children, an effect current health benefit analyses attempt to quantify. Mercury is also suspected of having a role in cardiovascular events (heart attacks in men), but insufficient evidence exists to quantify the extent of this effect. While much has been done in Minnesota and nationally to reduce mercury emissions, coal-burning power plants remain a major contributor to environmental mercury contamination. The Mercury Emissions Reduction Act and the new MATS will significantly reduce the potential contribution that Minnesota's coal-fired boilers have to fish contamination.

The Mercury Emissions Reduction Act requires that the MPCA evaluate the environmental and public health benefits related to the mercury-control project. Minn. Stat. § 216B.684(2).

The multi-pollutant control technology in the retrofit of the Boswell Unit 4 includes the instillation of a power activated carbon system and fabric filters to reduce mercury and PM emissions. As was seen in Table 7, the pollution control improvements at the Boswell Unit 4 are expected to reduce annual mercury emissions from 228 pounds to 26 pounds, a reduction of nearly 90 percent.

Past MPCA evaluations of emission-reduction plans for coal-fired power plants did not quantify benefits from mercury reductions, and the MPCA still cannot give a reasonable quantifiable estimate of benefits from mercury reductions, as can be done for $PM_{2.5}$. There are clearly significant environmental benefits from reduced mercury emissions but they cannot be quantified because available information does not support reasonable estimates. The MPCA can, however, discuss the benefits of mercury reductions in terms of their types and rates. This will not allow a direct comparison of site-specific benefits and costs, but it will suggest useful relative values.

Several institutions and investigators have invested considerable effort to quantify benefits of mercury reductions. Recently, EPA assessed the benefits of reduced mercury emissions nationally in its Regulatory Impact Analysis for the MATS rule.[21] One relatively recent publication has undertaken a thorough review of several mercury benefit studies.[22] Other recent studies that have examined the benefits of mercury emissions reductions, which we draw upon in this discussion, include:

[20] MPCA, 2012. http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/impaired-waters-list.html

[21] Available online at: http://www.epa.gov/mats/pdfs/20111221MATSfinalRIA.pdf

[22] Swain, Edward B., et. al., "Socioeconomic Consequences of Mercury Use and Pollution," *Ambio*, 36(1):45-61.

Northeast States for Coordinated Air Management (NESCAUM)	Glenn Rice and James Hammitt "Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants," February 2005 www.**nescaum**.org/documents/rpt050315mercuryhealth.pdf/
National Institutes of Health	Leonardo Trasande et. al. "Public Health and Economic Consequences of Methylmercury Toxicity to the Developing Brain," February 2005 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1257552/
Resources for the Future	Karen Palmer et. al. "Reducing Emissions from the Electricity Sector: The Costs and Benefits Nationwide and in the Empire State," June 2005 http://www.rff.org/rff/Documents/RFF-DP-05-23-Exec-Sum.pdf
US EPA	Charles Griffiths et. al. "A Comparison of the Monetized Impact of IQ Decrements from Mercury Emissions," June 2007 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1892144/

These studies vary with respect to methods and scope. Their benefit estimates differ because, although general understanding of mercury in the environment is reasonably clear, the specific details of cause and effect are uncertain. Some things are known beyond a reasonable doubt:

- Mercury is a potent neurotoxin.
- Mercury is deposited in Minnesota lakes and — while undergoing a complex environmental cycle — is converted to methylmercury and bioaccumulates in aquatic food chains.
- The predatory fish favored by fishermen have relatively high concentrations of mercury in their muscle tissue.
- Methylmercury transfers from pregnant women to their developing fetuses.
- Neural damage occurs with fetal exposure to methylmercury.

Other aspects of benefit estimates are more uncertain, requiring analysts to make assumptions about significant values such as:

- dose-response relationships that describe the connection between mercury exposure and declines in children's IQ scores
- mercury exposure rates in general populations and in distinctive subgroups
- lags in bioaccumulation of methylmercury in fish

Finally, some elements of benefit estimates fall into a "suspected, but not fully supported" category. These are the elements often referred to as unquantified benefits:

- reduction in heart attacks, both fatal and otherwise
- minimized damage to fish and fish-eating wildlife (loons, kingfisher, eagle, otter, mink, and others)

Given variance in study methods, it is not unusual to learn that they vary with respect to their findings. All of the listed studies estimate total values for benefits under different scenarios. Four of them base

their scenario analyses on assumed amounts of emission reductions. For example, each study estimates that if mercury emissions are reduced by x pounds, positive health effects will result with benefits valued in billions of dollars. We can calculate rates, in dollars per pound, for each estimate that make their findings somewhat comparable.[23] See Table 10.

Table 10. Estimated benefits of reduced mercury emissions

	Benefits related to avoiding declining IQ in children ($/lb)		Benefits related to reductions in heart attacks ($/lb)	
	Low	High	Low	High
Rae & Graham	$1,346	$1,368	$9,063	$9,437
Palmer et. al.	$2,000	$5,050	$500	$86,150
Rice & Hammitt	$1,630	$4,235	$1,043	$72,059
Griffiths et. al.	$4,038	$7,000		

The US Environmental Protection Agency (EPA) and others regard IQ-related benefits as having the best support. These benefits are generally modeled as changes in the IQ scores of children in affected communities. Benefit estimates in this category range from about $1,300 to $7,000/lb. Given the projected annual mercury emissions reduction for the Boswell Unit 4 of 202 pounds (Table 7), this ranges lead us to conclude the annual human health benefits from just avoiding declining IQ in children to be in the range of $270,000 to $1.4 million.

Another group of estimates relate mercury emission changes to heart attacks, both fatal and nonfatal. Studies supporting these estimates are more recent and less thoroughly tested than IQ-related studies. Benefit estimates related to cardiovascular effects are not considered as reliable as IQ-related estimates. When heart-related effects are taken into account, benefit estimates range from $500 to $86,000/lb. The wide range results because estimating models depend significantly on assumptions that vary quite a lot. Moreover, medical researchers debate whether avoiding the consumption of fish to avoid ingesting contaminants is sound health advice, given the benefits of eating fish. This wide range leads to an annual benefit estimates for reduced heart attacks from the Boswell Unit 4's projected mercury emission reductions in the range of $100,000 to $17 million.

On balance, we find that the weight of evidence supports a general finding that reducing mercury emissions will lead to economic benefits in terms of health improvements. However, the precise value of these benefits remains uncertain and comparisons based on the range of values between studies would not have strong foundations. Note also that, although benefit estimates remain uncertain, researchers continue to study all aspects of mercury's environmental impacts. As time goes by, we expect that uncertainties will decline to the point that we can endorse reasonable value estimates.

[23] Specific differences remain with respect to methods (e.g., dose-response functions, unit values for lost IQ points, monetary bases, assumptions about the value of a "statistical-life") and scope (e.g., national versus regional). These differences mean benefit rates should be viewed as informative rather than directly comparable.

Discussion of Net Benefits of the Boswell Energy Center Unit 4 Multipollutant Reduction Plan

Adding the likely economic benefits of reduced mercury emissions to these benefits totals increases the total economic benefits of the Boswell Unit 4 project by anywhere from $370,000 to $19 million. Even assuming the maximal value of mercury reductions along with the higher estimate for benefits of reduced $PM_{2.5}$, however, the costs of the Boswell Unit 4 plan exceed the benefits. Minnesota Power projects annualized costs of the Boswell Unit 4 plan to be nearly $66.8 million. As has been shown above, the annual benefits of the Boswell Unit 4 plan range from about $15 million to $50 million.

It is possible that there are non-quantifiable benefits, from other health impacts that were not part of the analysis and from welfare impacts such as ecosystem damage, visibility and materials damage, that would increase the actual benefits of this project beyond the estimates presented in this report. Given the current science to value the benefits of pollution control, however, MPCA finds that for air pollution subject to benefit valuation, the overall net social benefit of this project is negative since the total measurable costs exceed the total measurable benefits. Additionally, the MPCA's quantitative benefits valuation analysis of pollution improvements did not take into account recent improvements to the Boswell Unit 4 plant to reduce NO_x emissions.

6.0 Appropriateness of the Proposed Project

The MPCA is required by Minn. Stat. § 216B.684 (4) and Minn. Stat. § 216B.686 subd. 3(a)(3) to describe the overall appropriateness of a utility's plan for reducing mercury and other pollutants. We describe in this part the appropriateness of the proposed plan in light of federal power plant emission control programs and other considerations. We also describe why the project qualifies for the rate recovery provided by the Mercury Emissions Reduction Act.

Mercury Reductions

Minnesota Power's proposed project will meet the statutory goal of reducing mercury emissions from the Boswell Unit 4 by 90 percent. Minnesota utilities are well on their way to helping Minnesota meet its goal of reducing statewide mercury emissions. As currently scheduled, the Boswell Unit 4 will be the final utility retrofit project to be completed under the Mercury Emissions Reduction Act, and will bring statewide electric utility boiler emissions to under 200 pounds per year. The commissioning of this control project will result in a total reduction of 1300 pounds a year of mercury emissions since 2006 when the act was adopted.

Mercury emissions reductions from all sources are necessary to address water quality impairments. Minnesota's fish are contaminated with mercury. The plan to address those impairments, Minnesota Total Maximum Daily Load (TMDL) for mercury seeks a statewide reduction of mercury. The reduction of 200 pounds of mercury at Boswell will complete the scheduled reductions by Minnesota's utility sector according to the TMDL's implementation plan.

Federal Rules

This project will bring Minnesota Power's largest electricity generating unit into compliance with EPA's Mercury and Air Toxics Standard (MATS) rule. This air pollution control requirement for utilities has accelerated the time table to accomplish Minnesota's mercury reductions. The project is needed to address mercury and particulate matter emission limits of the MATS rule at the Boswell Unit 4.

The MPCA is aware of certain SO_2 emission information in Minnesota Power's possession that the MPCA is not at liberty to share unilaterally because of restrictions under the Minnesota Data Practices Act. To ensure this data is part of the record, the MPCA believes the MPUC should issue an Information Request to Minnesota Power regarding the basis for the Project's proposed SO_2 emission rate.

Minnesota Power's proposed plan includes changing from a wet process that results in a wet ash slurry to a dry process that results in dry ash. Pending federal regulations intend to manage the risks to human health and the environment from mismanagement of coal combustion residuals. EPA's intent is to phase out the use of existing surface impoundments of wet ash. Implementing this project will remove uncertainties regarding future regulations that may apply to the Boswell Unit 4 and its wet slurry ponds. This is not an insignificant benefit; current national cost estimates related to addressing wet ash ponds is in the billions of dollars. It is reasonable for Minnesota Power to anticipate this type of future regulatory action and move to dry solids handling.

Regional haze regulations addressing the visibility in Voyageurs National Park and other wild and scenic areas potentially will require continued emission reductions in SO_2 and NO_x from Minnesota sources. While the Boswell Unit 4 has been operating with good SO_2 controls, all SO_2 reductions will aid in achieving regional haze visibility goals. The impacts of these reductions are unknown until the MPCA completes it midterm status review on haze control actions in 2014 to submit a revised state

implementation plan to EPA by 2018. Emission reductions from all sources will be taken into account in this assessment.

Global climate change concerns are pressing for greenhouse gas reductions from this industry. The project is not designed with control of greenhouse gases in mind, however, a number of improvements will be made at the plant that Minnesota Power believes will increase overall energy efficiency. First, the semi-dry scrubber/fabric filter system is anticipated to have a lower electrical load than the existing air pollution control system, likely increasing unit efficiency post-project. Second, Minnesota Power describes potential energy efficiency benefits with the replacement of pumps, fans, and blowers, and has included energy efficiency experts in its design team.

The MPCA believes that this project is appropriate for accomplishing the objectives of reducing emissions of mercury and other pollutants under Minn. Stat. §§ 216B.68 to 216B.688, bringing the Boswell Unit 4 into compliance with federal air emission standards, resolving environmental violations, and avoiding additional regulatory requirements related to coal combustion residuals. Reduction of mercury will aid Minnesota in achieving its requirement to address water quality impairments related to mercury contamination of fish.

The MPCA recommends that the Minnesota Public Utilities Commission accept this report's findings.

Appendix 1: Mercury Emissions Reduction Act Statutory Language

216B.68 Definitions; Mercury Emissions Reduction
Subdivision 1 Scope

Terms used in sections 216B.68 to 216B.688 have the meanings given them in this section and section 216B.02.

Subd. 2.Agency.

"Agency" means the Minnesota Pollution Control Agency.

Subd. 3.Dry scrubbed unit.

"Dry scrubbed unit" means a targeted unit at which pollution control technology that uses a spray dryer and fabric filter system to remove pollutants from air emissions is installed or will be installed by December 31, 2007.

Subd. 4.Federal mercury regulations.

"Federal mercury regulations" means the federal Clean Air Mercury Rule as of January 1, 2006, published in Code of Federal Regulations, title 40, parts 60, 63, 70, and 72.

Subd. 5.Mercury emissions reduction.

"Mercury emissions reduction" means the amount of mercury reduced from the emissions of a targeted or supplemental unit, relative to the emissions baseline from that unit established under section 216B.681, expressed as a percentage.

Subd. 6.Qualifying facility.

"Qualifying facility" means an electric generating power plant in Minnesota that, as of January 1, 2006, had a total net dependable capacity in excess of 500 megawatts from all coal-fired electric generating units at the power plant.

Subd. 7.Start-up period.

"Start-up period" means a period of one year after the date mercury-control equipment is installed at a targeted unit under an approved mercury emissions-reduction plan, or such longer period as the commission may approve after consultation with the Pollution Control Agency, if a longer period is necessary to optimize equipment performance for mercury reduction.

Subd. 8.Targeted unit.

"Targeted unit" means a coal-fired electric generation unit greater than 100 megawatts at a qualifying facility.

Subd. 9.Wet scrubbed unit.

"Wet scrubbed unit" means a targeted unit at which pollution control technology that uses water or solutions to remove pollutants from air emissions is installed.

History:

2006 c 201 s 5

216B.681 Monitoring Mercury Emissions

By July 1, 2007, a public utility that owns or operates a qualifying facility shall install, maintain, and operate continuous mercury emission-monitoring systems or other method of monitoring approved by the agency on each targeted unit and, where applicable, on each supplemental unit pursuant to section 216B.6851. The monitoring systems must use methods set forth in federal mercury regulations or such other methods as may be approved by the agency. The public utility shall report to the agency as public data the quality assured data produced from monitoring implemented pursuant to this section on a quarterly basis in a form prescribed by the agency. The data from at least six months' monitoring must be used to establish a baseline for mercury emissions reductions under sections 216B.68 to 216B.688.

History:

2006 c 201 s 6

216B.682 Mercury Emissions Reduction Plans

Subdivision 1.Dry scrubbed units.

(a) By December 31, 2007, a public utility that owns a dry scrubbed unit at a qualifying facility shall develop and submit to the agency and the commission a plan for mercury emissions reduction at each such unit. At each dry scrubbed unit owned and operated by the utility, the plan must propose to employ the available technology for mercury removal that is most likely to result in the removal of at least 90 percent of the mercury emitted from the unit.

(b) A plan submitted under this subdivision must provide for mercury emissions reduction at each dry scrubbed unit to be implemented by December 31, 2010. A public utility that owns two dry scrubbed targeted units must submit a plan that provides for implementation at one unit by December 31, 2009, and at the other unit by December 31, 2010.

Subd. 2.Wet scrubbed units.

(a) By December 31, 2009, a public utility that owns a wet scrubbed unit at a qualifying facility shall develop and submit to the agency and the commission a plan for mercury emissions reduction at each such unit. At each wet scrubbed unit owned by the utility, the plan must propose to employ the available technology for mercury removal that is most likely to result in the removal of at least 90 percent of the mercury emitted from the unit.

(b) A plan submitted under this subdivision must provide for mercury emissions reduction at each wet scrubbed unit to be implemented by December 31, 2014.

Subd. 3.Mercury emissions plans generally.

(a) In each plan submitted under this section, a utility shall present information assessing that plan's ability to optimize human health benefits and achieve cost efficiencies. Each plan must provide the cost, technical feasibility, and mercury emissions reduction expected for the utility's preferred technology option and each alternative considered. The utility shall demonstrate that it has considered achieving the mercury emissions reduction required under this section through multiple pollutant control technology.

(b) A plan submitted under this section may also:

(1) provide measures to reduce the cost and maximize the flexibility of each option proposed or considered; and

(2) specify permit targets or conditions proposed by the public utility for each mercury emission-control option proposed or considered, including, but not limited to, numeric emission targets, percent removal expectations, emission control technology installation and operation requirements or work practice standards, and potential changes in the performance of the mercury emissions-reduction technology over time.

(c) The utility may submit an emissions rate rider to the commission under section 216B.683 to recover the costs associated with plans filed under this section.

History:

2006 c 201 s 7

216B.683 Mercury Emissions Reduction; Cost Recovery, Financial Incentives

Subdivision 1.Emissions-reduction riders.

(a) A public utility required to file a mercury emissions-reduction plan under sections 216B.68 to 216B.688 may also file for approval of emissions-reduction rate riders pursuant to section 216B.1692, subdivision 3, for its mercury control and other environmental improvement initiatives under sections 216B.68 to 216B.688.

(b) In addition to the cost recovery provided by section 216B.1692, subdivision 3, the emissions-reduction rate riders may include recovery of costs associated with (1) the purchase and installation of continuous mercury emission-monitoring systems, (2) costs associated with the purchase and installation of emissions-reduction equipment, (3) construction work in progress, (4) ongoing operation and maintenance costs associated with the utility's emission-control initiatives, including, but not limited to, the cost of any sorbent or emission-control reagent injected into the unit, (5) any project costs incurred before plan approval that are demonstrated to the commission's satisfaction to be part of the plan, and (6) any studies undertaken by the utility in support of the emissions-reduction plan.

(c) The utility may propose to phase in the emissions-reduction riders to recover these costs over the development and life of the projects.

Subd. 2.Performance-based incentives.

A mercury emissions-reduction rider approved by the commission may include performance-based financial incentives if the commission determines that the incentives will increase the likelihood that the utility will exceed 90 percent mercury emissions reductions, provided the incentives do not impose excessive costs on the utility's consumers when added to the costs recovered under subdivision 1. These incentives may include increased returns on investments or other performance-based incentives. The commission may structure the financial incentives to escalate for each additional increment of mercury emissions reduction achieved by the utility above the 90 percent mercury emissions reduction.

Subd. 3.Application of other law; associated rider.

(a) Section 216B.1692 applies to plans and emissions-control riders proposed under sections 216B.68 to 216B.688, except that:

(1) projects included in a plan approved under sections 216B.68 to 216B.688 are deemed to be qualifying projects for the purposes of section 216B.1692; and

(2) section 216B.1692, subdivisions 5, paragraph (c), and 6, do not apply to plans or riders submitted under sections 216B.68 to 216B.688.

(b) Commission approval of an emissions-reduction plan under this section includes approval of an emissions-reduction rider associated with that plan if submitted by the utility.

History:

2006 c 201 s 8

216B.684 Environmental Assessment of Mercury Emissions-Reduction Plan

The Pollution Control Agency shall evaluate a utility's mercury emissions-reduction plans filed under sections 216B.682 and 216B.6851 and submit its evaluation to the Public Utilities Commission within 180 days of the date the plan is filed with the agency and commission. In its review, the agency shall (1) assess whether the utility's plan meets the requirements of section 216B.682 or 216B.6851, as applicable, (2) evaluate the environmental and public health benefits of each option proposed or considered by the utility, including benefits associated with reductions in pollutants other than mercury, (3) assess the technical feasibility and cost-effectiveness of technologies proposed or considered by the utility for achieving mercury emissions reduction, and (4) advise the commission of the appropriateness of the utility's plan. In preparing its assessment, the agency may request additional information from the utility, especially with regard to alternative technologies or configurations applicable to the specific unit, and the estimated costs of those alternatives.

History:

2006 c 201 s 9

216B.685 Mercury Emissions-Reduction Plan Approval

Subdivision 1.Commission review and evaluation.

The Public Utilities Commission shall review and evaluate a utility's mercury emissions-reduction plans and associated emissions-reduction riders submitted under section 216B.682 or pursuant to subdivision 2, paragraph (b). In its review, the commission shall consider the environmental and public health benefits, the agency's assessment of technical feasibility, competitiveness of customer rates, and cost-effectiveness of the utility's proposed mercury-control initiatives in light of the Pollution Control Agency's report under section 216B.684.

Subd. 2.Commission approval.

(a) Within 180 days of receiving the agency's report on a utility's plan filed under section 216B.682, subdivision 1 or 2, the commission shall order the implementation of a utility's mercury emissions-reduction plan and associated emissions-reduction rider that complies with the requirements of the applicable subdivision of section 216B.682, unless the commission determines that the plan as proposed fails to provide for increased environmental and health benefits or would impose excessive costs on the utility's customers.

(b) If the commission is unable to approve the utility's plan and associated emissions-reduction riders as proposed, it shall direct the utility to amend and resubmit its proposed plan in light of the

record developed on the proposed plan or, at the utility's option, to file a new plan consistent with the requirements of the applicable subdivision of section 216B.682.

Subd. 3.Technical issues.

The commission shall give due consideration to the assessment of the Pollution Control Agency on compliance issues under sections 216B.68 to 216B.688, technical feasibility of emission-control technology, and environmental and public health benefits associated with emissions reductions.

Subd. 4.Equipment replacement; deadline extensions.

(a) Unless the utility proposes to do so, the commission may not require the replacement of existing pollution control equipment at a targeted or supplemental unit as a condition for approving a plan pursuant to this section or section 216B.6851.

(b) The commission may allow a utility up to two extensions of any deadline established under sections 216B.68 to 216B.688 or commission order under those sections, if the utility demonstrates the unavailability of necessary equipment or other extraordinary circumstances. An extension under this paragraph may last no longer than 12 months. The commission may not extend a deadline for final installation of pollution control equipment for longer than 12 months.

Subd. 5.Equipment optimization required.

A commission order under this section must require the utility to optimize the operation of equipment installed under a plan approved under this section to obtain maximum mercury reductions and to report the utility's efforts and results annually to the Pollution Control Agency, until such time as the agency determines the reports to be no longer necessary.

History:

2006 c 201 s 10

216B.6851 Utility Option

Subdivision 1.Election.

A public utility with less than 200,000 customers subject to sections 216B.68 to 216B.688 that owns two wet scrubbed units at a qualifying facility may opt to be regulated under this section for those units in lieu of section 216B.682. Plans under this section are subject to section 216B.682, subdivision 3. Except where otherwise provided, all other provisions of sections 216B.68 to 216B.688 apply.

Subd. 2.Supplemental unit.

"Supplemental unit" means a coal-fired electric generation unit at an electric generating power plant in Minnesota at which mercury emissions-reduction measures are taken as part of an emissions-reduction plan under this section.

Subd. 3.Plan for 90 percent reduction required.

A public utility that elects to be regulated under this section must file a mercury emissions-reduction plan that is designed to achieve total mercury reduction at targeted and supplemental units owned by the utility equivalent to a goal of 90 percent reduction of mercury emissions at the utility's targeted units by December 31, 2018.

Subd. 4.Alternative plans.

The utility shall also submit one or more alternatives to the 90 percent reduction plan required under subdivision 3. Alternative plans must be designed to come as near as technically possible to

achieving the goal established in subdivision 3 without imposing excessive costs on the utility's customers.

Subd. 5.Early action; wet scrubbed units.

(a) The utility electing for regulation under this section shall file an initial plan for mercury emissions reduction at one of its two wet scrubbed units on or before December 31, 2007. The plan must provide for mercury emissions reduction to be implemented at that unit by December 31, 2010. If the plan is approved by the commission, and implemented by the utility, the utility may have until July 1, 2015, to file its plans for reduction at its other wet scrubbed unit at the qualifying facility, and may have until December 31, 2018, to implement mercury emissions reduction at that unit.

(b) Until the utility files its plans for the other wet scrubbed unit, the utility must submit to the commission and agency, by July 1 each year, beginning in 2011, a report containing the following information:

(1) mercury control plans for units subject to this section, including how elements of the plans may affect the performance and cost-effectiveness of emission controls for air pollutants other than mercury;

(2) an assessment of the impacts of federal laws regulating various air pollutants emitted by coal-fired power plants that can reasonably be expected to be enacted by 2018 on the utility's units subject to this section, and potential utility responses to those laws, including, but not limited to:

(i) installing pollution control equipment;
(ii) using pollution allowances to achieve regulatory compliance; and
(iii) retiring or repowering the plant that is the subject of the filing with cleaner fuels considering the costs of complying with state and federal environmental regulations.

For each potential response, the report must include an analysis of the impacts on ratepayers, the utility's financial position, and utility operations, including the impacts on the service life of affected units.

(c) The utility shall consult with the agency, the Department of Commerce, and other interested stakeholders to determine which future federal laws to assess under paragraph (b), clause (2), and the scope of the assessment of the impact of those laws.

Subd. 6.Agency review and commission approval.

(a) The agency shall review the utility's plans as provided in section 216B.684.

(b) The Public Utilities Commission shall review and evaluate a utility's mercury emissions-reduction plans submitted under this section. In its review, the commission shall consider the environmental and public health benefits, the agency's determination of technical feasibility, competitiveness of customer rates, and cost-effectiveness of the utility's proposed mercury-control initiatives in light of the Pollution Control Agency's review under paragraph (a). Within 180 days of receiving the agency's report, the commission shall approve a utility's mercury emissions-reduction plan that the commission reasonably expects will come closest to achieving total mercury reductions at targeted and supplemental units owned by the utility equivalent to a goal of 90 percent reduction of mercury emissions at the utility's targeted units by December 31, 2018, in a manner that provides for increased environmental and public health benefits without imposing excessive costs on the utility's customers. If the commission is unable to approve the utility's 90 percent reduction plan filed under subdivision 3, the commission, in consultation with the Pollution Control Agency, shall order the utility to implement the most stringent mercury-control alternative proposed by the utility under this section

that provides for increased environmental and public health benefits without imposing excessive costs on the utility's customers.

(c) At each targeted and supplemental unit included in a plan under this section, a utility shall propose to implement mercury emissions-control measures that will result in the greatest reduction of mercury emitted from that unit that is technically feasible without imposing excessive costs.

History:

2006 c 201 s 11; 2010 c 325 s 2-4

216B.686 Other Environmental Improvement Plans

Subdivision 1.Utility filing.

(a) In order to encourage a utility to address multiple pollutants, a utility required to submit mercury-reduction plans under sections 216B.68 to 216B.688 may also propose plans for investments and related expenses in pollution control equipment to be installed at facilities in Minnesota needed to comply with state or federal emission-control statutes or regulations that became effective after December 31, 2004.

(b) For each plan, the utility must show that the investments in pollution control equipment to be installed at facilities in Minnesota under the plan will provide for increased environmental and public health benefits, do not impose excessive costs on the utility's customers, and will achieve at least the pollution control required by applicable state or federal regulations.

Subd. 2.Emissions-reduction riders.

A public utility that files a plan under this section may also file for approval of an emissions-reduction rate rider under section 216B.683, subdivision 1.

Subd. 3.Agency review.

(a) The Pollution Control Agency shall evaluate a utility's plans filed under this section and, within 180 days of receiving the filing, provide the commission with:

(1) verification that the emissions-reduction project qualifies under subdivision 1
(2) a description of the projected environmental benefits of the proposed project
(3) its assessment of the appropriateness of the proposed plans

(b) In preparing its review under this subdivision, the agency may request additional information from the utility, especially with regard to alternative technologies or configurations applicable to a specific unit, and the estimated costs of those alternatives.

Subd. 4.Commission approval.

The commission shall review and evaluate a utility's plans and associated emissions-reduction riders for other environmental improvement initiatives submitted under this section. The commission shall consider the overall environmental and public health benefits, total costs, and competitiveness of customer rates. Within 180 days of receiving the agency's report prepared under subdivision 3, the commission shall approve the plan and associated emissions-reduction rider if the commission finds that it meets the requirements of subdivision 1, paragraph (b).

History:

2006 c 201 s 12

216B.687 Mercury Emissions Reduction Implementation, Operation

Subdivision 1.**Permit conditions for mercury reductions.**

The agency shall establish the mercury emissions reduction for each targeted unit included in a plan approved under section 216B.685, or where applicable, for each targeted and supplemental unit included in a plan approved under section 216B.6851.

Subd. 2.Enforcement by agency.

(a) Except as required by federal regulation, any mercury reduction incorporated into the permit for a targeted unit as established under a plan approved under section 216B.685, or where applicable, for each targeted and supplemental unit included in a plan approved under section 216B.6851, must be a state-only condition of the permit and will not be enforced by the agency during the start-up period.

(b) After the start-up period ends, the Pollution Control Agency shall incorporate into the permit the mercury reduction reasonably expected to be achieved at each unit or facility as an enforceable state-only reduction. For a qualifying facility with multiple units that has one or more units included in approved plans, the agency may establish the mercury emissions reduction for the facility covering all targeted and supplemental units at that facility after the start-up periods for all units have concluded, and the actual mercury emissions for the units have been determined. In setting the reduction, the agency shall give due consideration to the results of monitoring before implementation of the plan, the results of monitoring during the start-up period, and any factors that may impact the performance of the unit for the next five years.

Subd. 3.Equipment optimization required.

The agency shall revise the unit's air permit every five years to ensure optimal mercury emissions reduction by equipment installed under an approved plan, in light of technical and operational advances made since the date of plan approval. In revising the unit's air permit, the agency may recommend, but shall not require, additional investments in pollution control equipment, or the removal of equipment installed pursuant to an approved plan. The utility may seek commission review of the costs associated with a permit requirement or request for equipment optimization proposed by the agency and, if review is requested, the revision is not effective until approved by the commission. The commission shall approve the revision unless the utility or other party shows that it will impose excessive consumer costs.

History:

2006 c 201 s 13

216B.688 Relationship to Other State Financial Requirements

Except as otherwise provided for equipment optimization as specified in section 216B.687, a public utility implementing an approved mercury emissions-reduction plan is not required to undertake additional investments or incur additional operating or maintenance costs to reduce mercury at a unit included in a plan approved under section 216B.685 or 216B.6851.

History:

2006 c 201 s 14

Appendix 2: BenMAP Model for Estimating the Public Health Benefits of Air Pollution Reductions

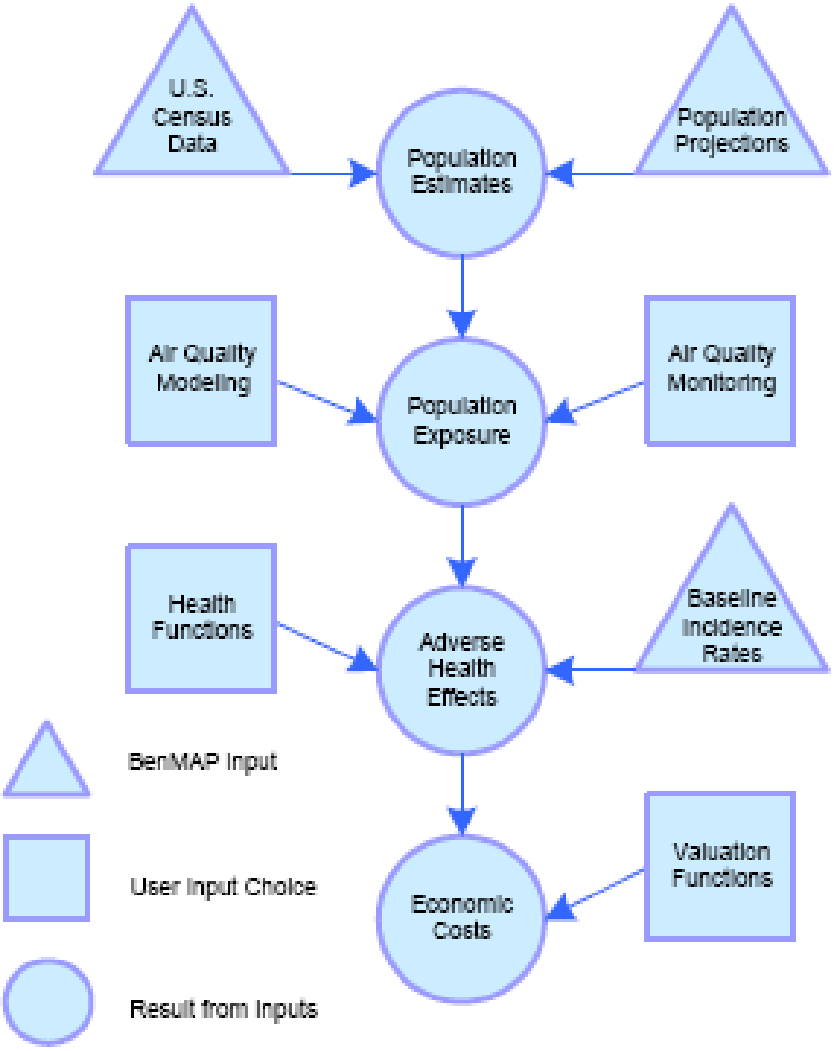
BenMAP Methodology and Modeling Assumptions

MPCA used BenMAP version 4.0.66 to assess the Boswell Energy Center Unit 4 multi-pollutant reduction plant[24]. The general steps and specific assumptions used for the analysis are described below. An overview of the systematic modeling process through which BenMAP proceeds is presented in Figure A-1. Following is an overview of each step of the process. Additional specific information about the air quality modeling and health effects calculations are presented after this overview.

- Define the geographic boundaries of the study area ("domain"). This analysis used the 12-kilometer domain for the main assessment. The domain is divided into "grid cells" to manage geographic changes in ambient air concentrations and population.
- Estimate air pollutant emissions before and after the emission-control project.
- Estimate the existing and post-control (before and after) air pollutant concentrations in the study area using emission estimates and air quality modeling. Average air pollutant concentrations are estimated for the selected modeling domain.
- Estimate how much $PM_{2.5}$ concentrations will decrease in the study area as a result of the Boswell 4 project by subtracting the post-control air pollutant concentrations from the existing ambient air concentrations.
- Estimate the number of people living in each grid cell. These people are assumed to be exposed to the average ambient air quality as estimated within their grid cells. BenMAP's population estimates are based on data from the 2010 U.S. Census, projected to future years.
- Baseline health incidence rate data for various adverse health effects (for example, hospitalization rates for different illnesses, mortality rates, and emergency room visits for asthma) are included in BenMAP. These measures of adverse health incidence rates are compiled by state and federal health surveillance systems or estimated from literature studies. The Boswell assessment was done using the national health incidence data set provided with BenMAP. Mortality rates are reported at the county level.
- Changes in air pollutant concentrations are related to changes in the incidence of adverse health effects using various "concentration-response" ("C-R") functions. These equations are based on the findings from many different epidemiological studies. They describe how much existing health impacts are expected to decrease as air pollutant concentrations are reduced.
- Valuation functions (generically like C-R functions) are used to estimate the monetary value of changes in health impacts. BenMAP's valuation functions derive from surveys of (a) respondents' willingness to pay for reduced risk of incurring health effects, (b) wage differences between jobs that involve different levels of health risks, and (c) costs related to direct health effects.

[24] BenMAP files are available from USEPA's BenMAP website: http://www.epa.gov/air/benmap/.

Figure A-1. BenMAP process: inputs and results



Source of Air Quality Input Data

The air quality modeling was conducted using the atmospheric chemistry and transport model Comprehensive Air Quality Model with Extensions (CAMx) version 5.41. Two scenarios were run: (1) a base case, and (2) the MP Boswell-control case. The base case consists of the 2007 baseK model inputs developed by the Midwest Regional Planning Organization (MWRPO) to evaluate $PM_{2.5}$ and ozone nonattainment. The 2007 baseK is based on the 2007 National Emissions Inventory data with enhancements. The MP Boswell-control case consists of the base case with the emissions adjustments applied to Unit 4 provided in Table 7.

CAMx was run with a 12km grid scale over a large portion of the United States. Figure A-2 below shows the spatial coverage of the grids. The 12km gridded affected area for which changes in ambient air quality concentrations were modeled encompasses all of Minnesota and portions of Canada, Michigan, North Dakota, South Dakota, Iowa, Wisconsin, Illinois and Nebraska.

Figure 4 shows the annual average modeled concentration change — in micrograms per cubic meter ($\mu g/m^3$) — between the base case and the MP Boswell-control case over the 12km grid. Although the MP-Boswell BenMAP study evaluated 24-hour averages, the annual average difference shown in Figure 4 provides an overall picture that the greatest air quality improvement occurs in the areas closest to MP-Boswell.

Estimating the Change in Health Impacts

BenMAP includes health functions for estimating the benefits of reducing ambient concentrations of fine particulate matter ($PM_{2.5}$), PM_{10} and ozone. These health functions derive from the epidemiology literature. They describe how much risks of the adverse health effects are expected to decrease in relation to improved air quality.

Concentration-response (C-R) response functions are mathematical descriptions of how exposed populations respond to changes in pollutant concentrations.[25] A simple form for a C-R function for particulate matter is:

$$HI = a + B(PM)$$

in which a health impact (HI) is estimated as the sum of all other influences (a) plus the rate of response (B) to a specified change in particulate concentrations (PM).

C-R functions can be more complex than this. BenMAP has a library of C-R functions that cover a list of health impacts. The list of health effects quantified in this evaluation is identical to the one the EPA used for its Regulatory Impact Assessment (RIA) for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter[26]. It includes:

[25] Concentration-response (C-R) functions are derived from epidemiology studies which assess the relationship between air pollutant concentrations and illness or mortality in human populations.

[26] "Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter", EPA–452/R-12-003, December 2012. http://www.epa.gov/pm/2012/finalria.pdf

- Premature mortality
- Nonfatal heart attacks
- Hospital admissions for cardiovascular and respiratory causes
- Emergency room visits for respiratory causes
- Acute bronchitis
- Lower respiratory symptoms
- Upper respiratory symptoms
- Work loss days
- Acute respiratory symptoms
- Asthma exacerbation

Estimating the Economic Values of Changes in Health Impacts

The U.S. Environmental Protection Agency (EPA) has extensive literature on economic valuation of health outcomes attributable to pollution, which itself draws on numerous primary sources from the economic valuation literature. A useful summary of the EPA's recommended approaches to economic valuation can be found in its 2010 publication *Guidelines for Preparing Economic Analyses*.[27] BenMAP utilizes the most credible and up-to-date economic valuation functions for the health impacts associated with $PM_{2.5}$ pollution. MPCA used the identical economic valuation functions used by the EPA in its RIA for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter.[28] In summary, all calculations to derive economic values of air pollution related health outcomes relied on peer-reviewed economic valuation data from EPA. Table A-1 gives an overview of the economic valuation functions to convert changes in health impacts to economic values used by MPCA to evaluate the Boswell Unit 4 multi-pollutant reduction plan. Approximate[29] monetary value per health incident is also indicated in the table.

[27] U.S. Environmental Protection Agency. (2010). Chapter 7: Analyzing Benefits. In *Guidelines for Preparing Economic Analyses*. Retrieved from http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html

[28] "Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter", EPA–452/R-12-003,December 2012. http://www.epa.gov/pm/2012/finalria.pdf

[29] Some economic values of some health impacts vary with location. (For example, when lost earnings is part of the valuation, average income levels vary by county.) The BenMAP analysis takes this geographic heterogeneity into account; the values presented in this table are approximate, and represent best estimates for the State of Minnesota.

Table A-1: Economic Valuation Methods to convert changes in health impacts from Boswell Unit 4 multi-pollutant reduction plan to economic values

Health Endpoint	Approximate Value/Incident (2010 US$)	Valuation Method
Premature Mortality	$8,900,000	What EPA currently uses for the value of a statistical life based on willingness to pay studies
Nonfatal Heart Attacks	$106,000	Based on cost of illness studies that consider medical expenses and lost earnings incurred over five years from the date of the event
Hospital Admissions, Respiratory	$24,000	Based on cost of illness studies that consider medical costs and lost earnings
Hospital Admissions, Cardiovascular	$33,000	
Emergency Room Visits, Respiratory	$370	Average of estimates from two cost of illness studies
Acute Bronchitis (Children)	$450	Derived from several willingness to pay studies of parents to avoid a typical illness for their children
Lost School Days	$85	Value of lost productivity of parent
Work Loss Days	$150	Based on county-specific median daily wages