Minnesota Pollution Control Agency

# Review of Xcel Energy's Sherco Units 1 and 2

# Mercury Reduction Plan

Minnesota Pollution Control Agency

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194
http://www.pca.state.mn.us
651-296-6300 or 800-657-3864 toll free
TTY 651-282-5332 or 800-657-3864 toll free
Available in alternative formats

## Authors and Contributors

**Policy**
Frank Kohlasch, Manager
Air Assessment and Environmental Management Section
Environmental Analysis and Outcomes Division
651-757-2500

**Technical, Regulatory and Cost Assessments**
Anne M. Jackson, P.E.
Principal Engineer
Environmental Analysis and Outcomes Division
651-757-2460

**Economic Analysis**
Robert McCarron
Economist
Environmental Analysis and Outcomes Division
651-757-2557

## For more information

Contact any of the above Minnesota Pollution Control Agency 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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# Review of Xcel Energy's Sherco Units 1 and 2 Plan Under the Mercury Emissions Reduction Act of 2006

## 1.0 Introduction

On December 21, 2010, Xcel Energy (Xcel) submitted an emission reduction proposal, the Mercury Control Plan for its Sherburne County Generating Plant (Sherco) Units 1 and 2, pursuant to Minn. Stat. § 216B.682.[1] Xcel proposes to operate powdered activated carbon sorbent injection by the statutory deadline of December 31, 2014.

This project, when implemented as proposed, will reduce mercury emissions from Sherco Units 1 and 2 by up to 90 percent overall, or the reduction of up to 440 pounds of mercury each year. Combined with mercury emission reductions already underway at Sherco Unit 3, total mercury emissions from the Sherco generating station will be reduced by about 80 percent overall. At the completion of this project in 2014, taconite facilities in northern Minnesota will become the largest emitting industry source of mercury to Minnesota's atmosphere.

While Xcel has committed to the installation of sorbent injection, the company has stated that it will continue to investigate other mercury control technologies, including multipollutant control strategies, and may amend this proposal to install a technology other than sorbent injection. The findings of this addition investigation and the development of federal air toxic pollutant control regulations will determine whether an amendment is necessary.

In this report, the Minnesota Pollution Control Agency (MPCA) provides the analysis of Xcel Energy's proposal that is required under the Mercury Emissions Reduction Act of 2006. Specifically, Minn. Stat. § 216B.684 tells the MPCA to advise the Minnesota Public Utilities Commission (PUC) as to the following:

- evaluate the environmental and human health benefits of the proposed mercury emissions-reduction project
- assess the technical feasibility and cost-effectiveness of the proposed mercury emissions-reduction project
- determine whether the plan meets the requirements of Minn. Stat. § 216B.682
- advise the Public Utilities Commission on the appropriateness of the plan

[Minn. Stat. § 216B.684]

The Mercury Emissions Reduction Act also encourages a utility to submit mercury-control plans that address controls of multiple pollutants (Minn. Stat. § 216B.686). Because Xcel Energy has not included in this plan air pollution control equipment to control pollutants other than mercury, the MPCA has not undertaken additional evaluations requested by Minn. Stat. § 216B.686, subd. 3.

### Order of document

To address each requirement of the Mercury Emissions Reduction Act, this document in Section 2.0 assesses the technical feasibility and cost-effectiveness of the mercury-reduction plan. We review estimated construction costs in Section 3.0, and then in Section 4.0 discuss environmental and health benefits. Lastly, in Section 5.0 we discuss the plan's overall appropriateness and whether it meets the requirements as described in the statute.

[1]The complete text of the statute is available at http://ros.leg.mn/bin/getpub.php?type=law&year=2006&sn=0&num=201.

## 2.0 Technical Assessment of Xcel Energy's Sherco Units 1 and 2 mercury reduction plan

Xcel Energy has submitted a plan for Sherco Units 1 and 2 located in Becker, Minnesota. The plan is being submitted to fulfill the requirements of Minn. Stat. § 216B.682.

Xcel Energy's Sherburne County station has three operating Electricity-Generating Units.
Units 1 and 2 are 690 MW and 685MW pulverized-coal units respectively, burning Powder River Basin subbituminous coal. Air emissions are controlled with a Wet Particulate Scrubber/Wet electrostatic Precipitator (WPS/WESP). The two components together are designed to control particulate matter emissions; Sulfur Dioxide ($SO_2$) control results from the inherent alkalinity of the fly ash to react with $SO_2$. Emissions from the two units each pass through their own air pollution control system, and are vented to a single common stack. A continuous mercury monitor has been installed in the stack and operating since July 2007.

Xcel Energy is the sole owner of Units 1 and 2.

## 2.1 Description of Xcel Energy's mercury reduction plan

Xcel Energy proposes to use sorbent injection to control mercury emissions. This method of removing mercury involves injecting sorbent, in this case Powdered Activated Carbon (PAC), into flue gases, allowing carbon to absorb mercury. PAC is captured along with coal fly ash in the WPS/WESP. Mercury captured in the ash will be collected and trucked to existing landfills. The novelty of this application of sorbent injection over other previous utility applications in Minnesota is the unique locations of sorbent injection into the boiler. In this case, PAC will be injected at a point further "upstream", between the economizer and the air preheater. At this point, PAC will be injected into a hotter flue gas stream and will be provided a longer retention period before being removed as particulate matter in the WPS/WESP than if the sorbent had been injected just prior to the PM control device. These two conditions improve the reactivity and contact time of the PAC in the flue gases.

Implementation of the technology involves constructing sorbent storage, piping, metering and injection equipment, and instrumentation and controls. Installation will occur during scheduled outages of several weeks

Continuous mercury monitors have been installed and are collecting mercury emissions data, as required by Minn. Stat. § 216B.681. At least six months of monitoring data must be used to establish a baseline from which mercury emission reductions will be measured to determine whether the removal goals have been achieved as required by the Mercury Emissions Reduction Act. This proposal is based on monitored mercury emission rate at the stack of 4.6 pounds per trillion Btu of heat input to the boilers (4.6 lb/TBtu), representing a current mercury removal efficiency of approximately 40 percent. This removal efficiency is higher than previously expected, and suggests that while reducing stack emissions by an additional 90 percent from current levels will be difficult, an overall removal of 90 percent is achievable with the proposed technology.

While Xcel has proposed a carbon injection process to control mercury, Xcel has stated that it intends to continue evaluating additional technologies. Xcel identified one mercury control technology and two multi-pollutant control technologies that it will be investigated. Because these technologies are not demonstrated at full scale capacity in the field, additional testing is necessary. As this project is required to be implemented by December 31, 2014, there is a fair amount of time to conduct testing and modify this project, if necessary.

## 2.2 Technical feasibility of Xcel Energy's mercury reduction plan

Mercury control technologies were previously identified in a mercury control assessment prepared for Xcel in 2007[2]. This assessment was submitted to the MPCA in support of an emissions reduction project contemplated by Xcel Energy in 2007. The assessment was conducted to determine the method most likely to achieve the goal of removing at least 90 percent of the mercury emitted from Sherco Units 1 and 2. The 2007 technical assessment of Sherco Units 1 and 2 forms the base of the mercury-control plan being proposed in this filing. Xcel updated the assessment and related costs for potentially feasible mercury control technologies.

The 2007 report described the process of selecting technologies to control mercury emission. The following issues were considered:

- technical feasibility
- cost of compliance
- energy and non-air quality environmental impacts of compliance
- other existing pollution-control equipment in use or installed at Sherco Units 1 and 2
- the remaining useful life of the unit

The analysis methodology consisted of the following steps:

(1) Develop the design basis.

(2) Identify all available retrofit control technologies.

(3) Eliminate technically infeasible options.

(4) Evaluate control effectiveness of remaining control options.

(5) Evaluate impacts and document results.

The design basis included assessing the technical characteristics of the flue gases from the boiler through the air pollution-control equipment, including mercury inputs.

Minnesota statutes require "…removal of at least 90 percent of the mercury emitted from the unit." (Minn. Stat. § 216B.682, subd. 1) Xcel identified 22 retrofit technologies that can be classified into three general mercury-control-technology groups: (1) reagent-based, (2) multipollutant and (3) emerging. Reagent-based mercury-control technologies are those that introduce a reagent into the boiler or flue gas to capture or enhance mercury removal. Multipollutant controls involve applying sorbents and new technologies that remove mercury in addition to other regulated pollutants at power plants. Emerging technologies are those that are in development but have not progressed beyond pilot scale demonstration.

Identified control technologies were assessed to determine whether the technology was both feasible and applicable to Sherco Units 1 and 2. At the completion of the technology assessment, six control options remained feasible for application at Sherco Units 1 and 2. The mercury control effectiveness of each of these technologies at Sherco was evaluated, and a cost-effective analysis of the technologies conducted.

### Mercury-reduction potential of selected technologies

Six technologies were identified as currently feasible and available for retrofitting at Sherco 1 and 2: (1) PAC injection, (2) brominated or halogenated powdered activated carbon injection (B-PAC), (3) coal-cleaning with B-PAC injection, (4) addition of a new fabric filter in front of the WPS/WESP, (5) addition of a new fabric filter in front of the WPS/WESP with B-PAC injection and (6) replacement of the existing WPS/WESP with a spray dryer/fabric filter.

[2]Black and Veatch. Sherburne County Generating Plant Units 1 and 2 Mercury Technology Assessment Study. December 18, 2007.

Table 1. Mercury emissions from Sherco Units 1 and 2 control alternatives

| | Lb/TBtu | Lb/yr at 40% removal | Lb/yr at 83% removal | Lb/yr at 90% removal |
|---|---|---|---|---|
| Existing conditions | 4.7 | 248.5 | | |
| PAC injection | 0.8 to1.36 | | 144 | 85 |
| B-PAC injection | 0.8 to 1.36 | | 144 | 85 |
| Coal-cleaning with B-PAC injection | 0.8 to 1.36 | | 144 | 85 |
| Add'l Fabric Filter in front of WS/WESP | 0.8 to 1.36 | | 144 | 85 |
| Add'l Fabric Filter in front of WS/WESP with B-PAC | 0.8 to 1.36 | | 144 | 85 |
| Replace Existing WS/WESP with Spray Dryer/Fabric Filter and B-PAC injection | 0.8 to 1.36 | | 144 | 85 |

**Activated carbon injection**

Three technologies evaluated rely in whole or part on powdered activated carbon injection for the control of mercury. The March 2009 inventory of mercury control projects maintained by the Institute of Clean Air Companies shows that 98 of 100 mercury control projects currently ordered or installed at utility boilers are PAC-based projects.[3]

Both PAC and B-PAC have been demonstrated to achieve greater than 90 percent control of mercury. The more sorbent that is injected, the more mercury removed until overall removal is about 95 percent. Less B-PAC is required to achieve these removal rates than PAC, however at this facility the use of B-PAC could lead to the need for additional treatment of the scrubber water. Xcel has not yet determined whether a scrubber water system is needed, and so at this time Xcel intends to use PAC as the sorbent upon startup of the sorbent injection system.

**Installation of fabric filter in front of WSP/WESP with and without carbon injection**

In this option, a fabric filter would be installed between the boiler and the existing WSP/WESP. The fly ash would be captured on the fabric filter, and is expected to change the elemental mercury in the flue gas to oxidized mercury so that it is more readily removed in the WSP/WESP device. Xcel conducted pilot tests of this technology to demonstrate the chemical reactions and removal efficiency of this technology. Adding small amounts of carbon improved both the oxidation of mercury and the overall removal efficiency.

This is identified as two distinct alternatives because the injection of carbon introduces an additional capital expense (although small) for sorbent storage and injection equipment as well as an additional ongoing chemical purchase expense.

**Replace WSP/WESP with a spray dryer/fabric filter with carbon injection**

This option would make Sherco Units 1 and 2 similar to Sherco 3; the wet system of air pollution controls would be removed and a lime spray dryer for $SO_2$ control and fabric filter for particulate matter control would be installed in its place. Mercury would then be controlled by injecting carbon to react with

[3] http://www.icac.com/files/public/Hg_Commercial_Bookings_033009_Public.pdf Accessed April 22, 2009.

mercury so that the mercury is captured in the fabric filter. Mercury removal efficiencies with this technology have been demonstrated to be well over 90 percent.[4]

### Summary

The MPCA believes that Xcel and its engineering consultant conducted its technology assessment in an appropriate manner. Xcel has identified demonstrated mercury removal technologies for Units 1 and 2, including evaluating multipollutant controls, and has weighed site and technology limitations appropriately. Pilot testing at Sherco and elsewhere shows that the identified technologies will likely achieve similar mercury reductions, suggesting that in the absence of seeking multipollutant reductions, the selection of technology might be based solely on cost of implementation.

## 2.3 Cost-effectiveness analysis of mercury controls

The six technologies found to be feasible at Sherco Units 1 and 2 were evaluated for cost-effectiveness. The estimate of the amount of mercury reduced assumes an operating capacity of 85 percent for each unit.

Table 2. MPCA Assessment of Cost-Effectiveness of Mercury Control Alternatives at Sherco Units 1 and 2

| **Control Alternative** | **Total Annual Cost, per unit ($1000)** | **Mercury reduced, lb/yr per unit** | | **$/lb Mercury reduced** | |
|---|---|---|---|---|---|
| | | 83% control | 90% control | 83% control | 90% control |
| PAC | 5,910 | 177 | 206 | 33,470 | 28,664 |
| B-PAC | 5,910 | 177 | 206 | 33,470 | 28,664 |
| Add'l FF in front of WESP/WS | 28,550 | 177 | 206 | 161,688 | 138,471 |
| Add'l FF in front of WESP/WS w/B-PAC | 29,150 | 177 | 206 | 165,086 | 141,381 |
| replace WESP/WS with SD/FF/ACI | 40,800 | 177 | 206 | 231,064 | 197,886 |
| coal cleaning with ACI | 66,400 | 177 | 206 | 376,045 | 322,049 |

Total annual costs of the control technologies include chemical purchase, labor and capital recovery. The cost per pound of mercury removed decreases with the improvement in mercury removal. The use of activated carbon injection results in the lowest cost per pound of mercury removed.

## 2.4 Summary

The MPCA concurs with Xcel Energy's technical assessment of mercury controls. Xcel Energy has accurately described the current status of mercury control development in its filing. A number of control technologies are in development, but sorbent injection at this time has the broadest application in the utility industry, and has been demonstrated at full-scale testing to achieve the very high mercury removal goal set by the Mercury Emissions Reduction Act.

Xcel has selected the least-cost alternative that has the greatest potential of achieving the statutory goal of 90 percent reduction of mercury emissions at Sherco Units 1 and 2.

[4]Jones, A. et. al. DOE/NETL's Phase II Mercury Control Technology Field Testing Program Updated Economic Analysis of Activated Carbon Injection. May 2007. http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/pubs/Phase_II_UPDATED_Hg_Control_Economic_Analysis.pdf Accessed April 7, 2008.

# 3.0 Estimated capital and annual cost of the proposals

The MPCA reviewed the cost of the proposed project and alternatives to determine whether the estimated costs are reasonable. Both annual and capital costs were reviewed to determine whether they are within a reasonable range for the size and nature of the project.

## 3.1 Method of analysis

The Mercury Emissions Reduction Act requires the MPCA to assess the cost-effectiveness of mercury controls. In section 2, we examined the cost-effectiveness of mercury reduction, as required by Minn. Stat. § 216B.684, item (3).

While site-specific conditions are critical to the cost of a project, given the recent emission reduction projects recently completed in Minnesota, utility retrofit project costs are fairly well understood.

Xcel Energy relied on recent incurred costs at its Sherco Unit 3 to develop capital and operating costs for the proposed project. Xcel Energy operates Unit 3 and has recently deployed PAC injection at Sherco Unit 3 for mercury control. The costs incurred for Sherco 3 were used to develop the cost of controls for Units 1 and 2. The MPCA views the cost estimates for Units 1 and 2 to be highly reliable due to this recent experience.

Cost estimates for other mercury reduction alternatives were prepared on Xcel's behalf by engineering consultants familiar with the type of controls and scale of project. Initial cost estimates were prepared in 2007 by Black and Veatch for Xcel Energy[5], updated to recent project conditions by URS and modified by Xcel based on its recent experiences with equipment purchase and installation[6]. Capital cost estimates include all costs related to the project, including engineering, contingencies and allowance for funds during construction. Annual costs include additional ash disposal, albeit very small; some auxiliary power for pumps, meters, fans; reagent purchases (activated carbon, for instance) and emissions testing. Vendors provided estimates of capital and certain annual costs; Xcel's consultant made some adjustments based on experience with past projects. The estimates are order of magnitude, meaning that costs could change as engineering is completed or volatility in costs continues. Xcel did not use retrofit multipliers to account for complicated construction conditions.

Table 3. Capital and annual costs of mercury control alternatives at Sherco Units 1 and 2

| Control Alternative | Capital Cost per Unit ($1000) | $/kW | Annual Capital Recovery ($1000) | Annual Operation and Maintenance ($1000) | Total Annual Cost ($1000) |
|---|---|---|---|---|---|
| PAC | 6,000 | 8.7 | 610 | 5,300 | 5,910 |
| B-PAC | 6,000 | 8.7 | 610 | 5,300 | 5,910 |
| Add'l FF in front of WESP/WS | 250,000 | 362 | 25,350 | 3,200 | 28,550 |
| Add'l FF in front of WESP/WS w/B-PAC | 254,000 | 368 | 25,750 | 3,400 | 29,150 |
| replace WESP/WS with SD/FF/ACI | 289,000 | 419 | 29,100 | 11,700 | 40,800 |
| coal cleaning with ACI | 210,500 | 305 | 21,200 | 45,200 | 66,400 |

Cost analyses for Sherco assume a fixed injection rate to achieve the 90 percent removal of mercury contained in the coal burned. Xcel estimated the annual cost of sorbent injection by relying on vendor estimates of sorbent injection rates for achieving 90 percent removal. Improvements in both removal

[5]2007 Black and Veatch study

[6]Rosvold, Richard. Personal Communication April 16, 2010.

efficiencies and sorbent use will develop from long-term performance assessment of the mercury-control technology.

The MPCA notes that Minn. Stat. § 216B.685, subd. 5. directs the Commission to include in its orders approving the mercury-reduction plan and rate rider a requirement of Xcel to optimize the system to maximize mercury reductions and to report the efforts and results annually to the MPCA. These reports will be a useful avenue for Xcel to report on its efforts to optimize mercury control, in terms of both achieving the goal of 90 percent reduction in mercury and any developments related to types and amounts of sorbents being used to achieve reductions.

## 3.2 Summary

Cost estimates for the Sherco Units 1 and 2 project prepared by Xcel Energy and/or its consultant appear to be reasonable. The estimates were generated using reliable data sources and standard estimating procedures and tools. The MPCA believes that Xcel Energy 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 projects.

# 4.0 Assessment of benefits of Sherco Units 1 and 2 mercury reduction plan

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, item (2).

Mercury emissions contribute to fish consumption advisories and water quality impairment via atmospheric deposition on lakes, rivers and contributing watersheds. The MPCA's 2004 impaired waters list identifies 419 river reaches and 820 lakes in Minnesota as impaired because the fish in them are contaminated with mercury[7]. While much has been done in Minnesota and nationally to reduce mercury emissions, coal-burning power plants remain a major contributor to mercury contamination of the environment. The Mercury Emissions Reduction Act begins to address the potential contribution of Minnesota's coal-fired boilers to fish contamination in Minnesota and elsewhere.

The selection of sorbent injection technology results in likely reductions of mercury at the Sherco generating station as described in the table below. Mercury emissions from electric generating units are reported annually to the MPCA as required by Minn. Stat. § 116.925, and recently as monitored by continuous mercury monitors under Minn. Stat. 216B.681. Current emissions in Table 4 reflect the average annual emissions measured by continuous mercury monitors from each unit at Sherco from January 2008 to December 2009. The percent reduction is less than 90 percent because the units are removing some mercury already, making it difficult to achieve a further reduction of 90 percent.

Table 4. Annual mercury emissions for Xcel Energy Sherco generating station (average of 2008 to 2009 data)

| | **Mercury (lb.)** | **Mercury (lb.)** |
|---|---|---|
| | **Average per year** | **After Mercury Controls** |
| Sherco 1 and 2 (common stack) | 445 | 85 to 144 |
| Sherco 3 (preliminary 2010) | 200 | 30 to 60 |
| Total annual emissions at Sherco plant | 645 | 115 to 204 |
| Percent reduction at Sherco generating station | | 78 to 82% |

[7]MPCA, 2004. www.pca.state.mn.us/publications/wq-iw4-01a.pdf

The Mercury Emissions Reduction Act does not require either the MPCA or the Commission to conduct a formal benefit-cost analysis. Although past evaluations of emission-reduction plans have made quantified benefit estimates when they are practical and reasonable, the MPCA and others have taken care to note that a number of environmental benefits cannot be quantified because available information does not support reasonable estimates. Since our benefit estimates are necessarily incomplete and uncertain in some respects, the MPCA has considered them as informative and advisory discussions, rather than evidence of whether a plan meets a legislated standard. This position fits well with conventional practice in benefit-cost analysis.

> [N]o CBA (Cost-Benefit Analysis) can by itself capture all factors relevant to all decisions. Data will be missing or of questionable validity. Uncertainty about the future will exist. There will be effects that are difficult to quantify. The decision may be one in which the role of CBA is limited as there are fundamental value questions at stake not best addressed by CBA. Finally, decisions are the responsibility of those elected or appointed to make them, and not the responsibility of an economic algorithm. For these reasons, the proper view of CBA is that of furnishing information to the decision process and not as providing the decision.[8]

The MPCA has relied on a set of recent studies:

| | |
|---|---|
| **Northeast States for Coordinated Air Management (NESCAUM)** | Glenn Rice and James Hammitt<br>"Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants," February 2005<br>www.**nescaum**.org/documents/rpt050315mercuryhealth.pdf/ |
| **National Institutes of Health** | Leonardo Trasande et. al.<br>"Public Health and Economic Consequences of Methymercury Toxicity to the Developing Brain," February 2005<br>http://www.ehponline.org/docs/2005/7743/abstract.html |
| **Resources for the Future** | Karen Palmer et. al.<br>"Reducing Emissions from the Electricity Sector: The Costs and Benefits Nationwide and in the Empire State," June 2005<br>http://www.rff.org/rff/Documents/RFF-DP-05-23-Exec-Sum.pdf |
| **U.S. EPA** | Douglas Rae and Laura Graham<br>"Benefits of Reducing Mercury in Saltwater Ecosystems," January 2004<br>http://www.cleanairnow.org/pdfs/officewatermerc.pdf |
| **U.S. EPA** | Charles Griffiths et. al.<br>"A Comparison of the Monetized Impact of IQ Decrements from Mercury Emissions," June 2007<br>http://www.ehponline.org/docs/2007/9797/abstract.html |

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.

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[8]R.O. Zerbe, 2007. "The Legal Foundation of Cost-Benefit Analysis" ExpressO Available at: http://works.bepress.com/richard_zerbe/2

- 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, 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. The MPCA has calculated rates, in dollars per pound, for each estimate to make their findings somewhat comparable. 9 See Table 5.

Table 5. 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 U.S. 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.

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.

[9]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.

On balance, the MPCA 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. Although available research shows estimates that present a range of values, methodological idiosyncrasies mean that each point between studies has a more or less equal likelihood. 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, the MPCA expects that uncertainties will decline to the point that the MPCA can endorse reasonable value estimates.

# 5.0 Appropriateness of the proposed project

The MPCA is required by Minn. Stat. § 216B.684, item (4), to describe the overall appropriateness of a utility's plan for reducing mercury. In this part, we describe our assessment of the state and federal power plant emission-control programs and how Xcel Energy's mercury control plan for Sherco Units 1 and 2 addresses those program requirements. We also describe why the project qualifies for the rate consideration provided by the Mercury Emissions Reduction Act.

## 5.1 Reducing mercury emissions from sources in Minnesota

The Mercury Emissions Reduction Act of 2006 directs Xcel to implement controls to achieve the goal of reducing mercury emissions by 90 percent. This action will support Minnesota's efforts to remediate waters in Minnesota impaired by mercury contamination.

Section 303(d) of the Federal Clean Water Act requires every state to prepare a list of impaired waters. Minnesota's 2004 303(d) List ("Impaired Waters List") includes water quality impairments in 1,892 lakes and river reaches. Two-thirds of those waters are impaired because of mercury. The 1,239 impairments by mercury consist of 820 lake impairments and 419 river impairments. Twelve lakes and 20 river reaches are impaired for mercury in fish tissue and in the water column; 808 lakes and 399 river reaches are impaired for fish tissue only.

Each impaired water is required to have a Total Maximum Daily Load Study (TMDL). The TMDL is an evaluation of (1) pollutant sources, (2) pollutant load reduction needed to meet water-quality standards and (3) allocation of the acceptable load to all sources. The source of essentially all mercury in Minnesota waters is atmospheric. Seventy percent of atmospheric mercury deposition is from anthropogenic sources (i.e., from human activities) and the remaining 30 percent is from natural sources, such as volcanoes. Minnesota's TMDL mercury emissions goal is to lower mercury emissions from Minnesota sources to 789 lb. per year. Atmospheric mercury emissions in 2005 are estimated to be 3,314 lb. per year from all sources in Minnesota. The EPA approved Minnesota's TMDL study for mercury-impaired waters on March 27, 2007.

The MPCA and a stakeholder group developed strategies to reduce emissions of mercury to the atmosphere from sources within Minnesota to achieve the reduction goal established in the TMDL by 2025. A key component of achieving the EPA-approved reduction goal is the control of mercury emissions from electric-generating units. Emissions in 2005 from Sherco Units 1 and 2 represent ten percent of mercury emissions from electric-generating units, and nine percent of all mercury emissions in Minnesota. Implementing this proposal will result in considerable progress in achieving the TMDL reduction goal.

When the Mercury Reduction Act was enacted in 2006, activated carbon injection was viewed as potentially unworkable for utility units using wet particulate matter controls. In the meantime, investigation undertaken by Xcel has pushed the development of the carbon injection control technology, demonstrating that carbon injection is technically feasible, and is likely to meet the mercury reduction goal.

## 5.2 Federal emission-control regulations

In the period between the submittal of this plan (December 21, 2009) and the date by which this plan is required to be implemented (December 31, 2014), the EPA is expected to promulgate hazardous air pollutant control standards to address emissions of Hazardous Air Pollutants (HAPs) from utility boilers, including mercury. At this point it is difficult to know what, if any, additional controls for HAPs will be required for these units. The MPCA expects that the standards will require aggressive control for hydrogen chloride (an acid gas controlled similarly to $SO_2$), very good particulate matter control for non-volatile metals, in addition to mercury controls. These future standards may require additional equipment on Sherco 1 and 2, putting Xcel into the situation of needing to modify this mercury control plan to account for these emission standards.

Xcel has investigated additional air pollution controls in its technology assessment for mercury, including multipollutant controls. Xcel described several potential candidates that Xcel will continue to investigate, and has provided budgetary estimates for additional pilot scale testing at the facility.

This proposal implements a technology that the generating industry is favoring for mercury control, for new units as well as a retrofit technology, and represents a low-cost investment. Given the continuing requirement under future federal regulations to control mercury, the minimal disruption and capital cost that this proposal represents, and the likelihood that this technology will meet future federal standards, the MPCA believes this plan is an appropriate means of meeting the goals of the Mercury Emissions Reduction Act.

## 5.3 Qualification of the project

The Mercury Emissions Reduction Act in Minn. Stat. § 216B.684 directs the MPCA to assess whether the utility's plan meets the requirements of Minn. Stat. § 216B.682.

Minn. Stat. § 216B.682, subd. 3(a) states:

> 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.

Xcel interprets the statute's requirement to "optimize human health benefits and achieve cost efficiencies" as achievement of the 90 percent reduction goal. In other words, health benefits are optimized when planners identify control systems that will reduce mercury emissions by 90 percent.

Because Xcel's preferred option represents the least-cost method most likely to achieve the reduction goal that was set by the legislature out of concern for human health, we find that Xcel Energy has met its responsibility under Minn. Stat. § 216B.682.

Xcel evaluated the cost, technical feasibility and emissions reduction for its preferred option and alternatives. Xcel will address any additional pollutant reductions through other emission-control plans.

The MPCA believes that Xcel has met the requirements of Minn. Stat. § 216B.682.

## 5.4 Summary

The MPCA believes that Xcel Energy's plan for reducing mercury at Sherco Units 1 and 2 is appropriate. The mercury reduction is substantial and will help achieve the mercury reductions needed to address contamination of fish in Minnesota lakes. The project represents a low-cost means of achieving that reduction and will likely meet the Mercury Emissions Reduction Act's goal of 90 percent reduction of mercury from Sherco Units 1 and 2.