PUBLIC

MidAmerican Energy Company

Electric Power Generation Facility Budget Update

for January 1, 2020 through December 31, 2029

Submitted to the Iowa Utilities Board: April 1, 2020

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EXECUTIVE SUMMARY

Iowa Code §476.6(19) requires rate-regulated utilities to develop a multi-year plan and budget for managing regulated emissions from their coal-fueled facilities in a cost-effective manner, and file updates at least every two years.

MidAmerican Energy Company ("MidAmerican") filed its initial Environmental Plan and Budget on April 1, 2002. MidAmerican has filed Environmental Plan and Budget Updates with the Iowa Utilities Board ("Board") at least biennially since this time, and all have been previously approved by the Board. The last Environmental Plan and Budget Update covered 2018 to 2020 and was filed on April 2, 2018.

This 2020 Budget Update, covering the period from January 1, 2020 through December 31, 2022, and including future plans through December 31, 2029, provides updates to environmental investments in MidAmerican's operated coal-fueled power plants during the subject period.

Throughout the 2020 Budget Update, the costs shown reflect the total plant costs, which are then allocated to joint owners unless they are identified as MidAmerican-only costs. The table below shows MidAmerican's share of total capital and operation and maintenance ("O&M") during the plan period.

MidAmerican's Share of Investments
included in the 2020 Budget Update
Calendar Years 2020 – 2022

Year	Planned Capital	Planned O&M
2020	[redacted]	[redacted]
2021	[redacted]	[redacted]
2022	[redacted]	[redacted]
Total	[redacted]	[redacted]

O&M expenditures listed above are largely costs associated with the dry scrubber, baghouse, and mercury control operations at Walter Scott, Jr. Energy Center ("WSEC") Unit 3, George Neal Energy Center ("Neal") Unit 3, Neal Unit 4 and Louisa Generating Station ("Louisa"), as well as costs associated with the operation of Selective Non-Catalytic Reduction ("SNCR") systems at Neal Unit 3 and Neal Unit 4.

In addition, MidAmerican will be responsible to pay a share of the costs of the Ottumwa Generating Station ("OGS") emission reduction projects. The plan and budget amounts for 2020-2022 for OGS are expected to be included in the Interstate Power and Light Company Environmental Plan and Budget.

The 2020 Environmental Plan and Budget Update fully complies with the requirements of Iowa Code 476.6(20) since:

- The Environmental Plan and Budget Update demonstrates that MidAmerican meets applicable state environmental requirements;

- The Environmental Plan and Budget Update is reasonably expected to achieve cost-effective compliance with applicable state environmental requirements and federal ambient air quality standards; and

- The Environmental Plan and Budget Update reasonably balances costs, environmental requirements, economic development potential, and reliability of the electric generation and transmission systems.

The next update to the Environmental Plan and Budget Update is expected to be filed by the statutory required date, or earlier if changes to key assumptions or regulatory drivers force significant alterations to the Environmental Plan or Budget.

I. MIDAMERICAN'S BUDGET

A. PAST PROJECTS

By way of background, the projects below were listed in prior approved Environmental Plan and Budget Updates. Each has been completed and the project closed out.

(1) Neal Unit 4 Scrubber and Baghouse was completed and closed in 2017.

(2) Neal Unit 4 Turbine Efficiency Upgrade Project was completed and closed in 2016.

(3) Neal Unit 3 Scrubber and Baghouse was completed and closed in 2017.

(4) Neal Unit 3 Turbine Efficiency Upgrade Project was completed and closed in 2016.

(5) Neal Unit 3 SNCR Project was completed and closed in 2017.

(6) Neal Unit 4 SNCR Project was completed and closed in 2017.

(7) Neal Unit 3 ACI Project was completed and closed in 2017.

(8) Neal Unit 4 ACI Project was completed and closed in 2017.

(9) Louisa ACI Project was completed and closed in 2016.

(10) WSEC Unit 3 ACI Project was completed and closed in 2016.

B. DEVELOPMENT OF THE 2020 BUDGET UPDATE

MidAmerican based its budget update for 2020 on reasonable forecasts for operations and maintenance of the emissions controls installed. This includes cost estimates for reagent chemicals, maintenance activities such as baghouse bag inspection and replacement, and general equipment maintenance.

C. DESCRIPTION OF EMISSION CONTROL TECHNOLOGIES

1) Dry Scrubber

In a dry scrubber, a lime reagent is used to form calcium hydroxide slurry. The slurry contacts the flue gas when it is sprayed as fine droplets in a spray dryer absorber vessel. The spray dryer absorber vessel is installed in the flue gas ductwork upstream of the particulate collection device. It has sufficient residence time to allow the sulfur dioxide in the flue gas to react with the lime as the water droplets evaporate, forming a dry byproduct – calcium sulfite. This byproduct is collected in the bottom of the spray dryer vessel and in the downstream particulate collection device. A portion of the collected dry solids is often recycled in the spray dryer to minimize lime reagent utilization. The collected dry solids are typically transported to a landfill disposal site, however alternative beneficial uses are currently being sought.

The primary particulate collection device utilized in these systems is a pulse-jet fabric filter baghouse. The use of the baghouse optimizes the sulfur dioxide removal efficiency, since some of the sulfur dioxide removal actually occurs within the filter cake on the baghouse filter bags.

The cost of the lime reagent is higher than the limestone typically used in wet scrubber systems; however the dry scrubber capital cost is approximately 20%-30% less than a wet scrubber system and utilizes less auxiliary power. Maximum sulfur dioxide removal with a dry scrubber and baghouse combination is typically 90% or an outlet concentration of 0.08 lb/mmBtu (whichever is limiting).

The operations and maintenance costs for this control is comprised primarily of lime reagent, replacement of bags in the baghouse, transport of waste ash and scrubber solids to the on-site landfills, and maintenance of various dry scrubber equipment such as slurry pumps, slaking equipment and electrical equipment.

2) Low Nitrogen Oxide Burners

Low Nitrogen Oxide Burners ("LNBs") reduce nitrogen oxide formation by reducing the amount of air in the primary combustion zone. This creates a fuel-rich reducing environment in the zone and lowers the peak flame temperature, both of which reduce nitrogen oxide formation. The balance of the air required for complete combustion is introduced around the primary combustion zone where the fuel/air mixture has dropped to less than 2800ºF. The lower fuel/air temperature at this point minimizes additional nitrogen oxide formation.

LNBs have been widely employed as an economical means to achieve moderate nitrogen oxide reduction. Of the 239 existing units subject to the 1996 Title IV (Acid Rain Program) Phase I nitrogen oxide limitations, 141 units, or 59%, utilized LNBs to meet the emissions limits. LNBs have been installed in all currently operated coal-fueled generating stations in MidAmerican's fleet. Nitrogen oxide reductions reported with LNBs typically range from 10% to 50%.

The operations and maintenance costs for this control are comprised of maintaining the LNB equipment during plant outages. Since there would be maintenance expense for burners whether they were LNBs or not, no specific O&M costs are shown for LNB. There is very little to no cost for the LNBs during operation as there are no reagents involved.

3) Overfire Air System

The operating principle behind overfire air ("OFA") is to divert a portion of the existing combustion airflow away from the burners and up to air injection ports located above the top burner elevation. The resultant combustion air staging reduces nitrogen oxide because the burners are operated with lower air-to-fuel ratios, e.g., fuel rich. This locally limits oxygen availability thereby reducing nitrogen oxide formation at the burners. OFA further reduces nitrogen oxide formation by delaying fuel and air mixing. OFA systems do not reduce the total amount of combustion air but merely redistribute a portion of the air away from the burner zone.

OFA is categorized as separated OFA ("SOFA") or close-coupled OFA ("CCOFA") depending on the burner and OFA port arrangement. SOFA systems involve installation of air port penetrations in the boiler waterwalls at an elevation about 8 feet to 15 feet above the top row of burners, whereas CCOFA ports are located immediately above the burners. All of MidAmerican's low nitrogen oxide projects utilized the more effective SOFA design.

OFA technology is applicable to all pulverized coal boiler types and therefore to all of the MidAmerican units. Although the nitrogen oxide reductions achieved with OFA are generally modest, OFA is relatively inexpensive to retrofit. OFA is often used in conjunction with LNBs and other nitrogen oxide technologies as low cost methods of reducing nitrogen oxide. SOFA produces greater nitrogen oxide reduction than CCOFA due to the higher degree of combustion staging. A reduction in nitrogen oxide emissions of 10% to 30% is typical for OFA. All of the coal-fueled units in the MidAmerican fleet utilize OFA.

The operations and maintenance costs for this control are comprised of maintaining the OFA equipment during plant outages. There is very little to no cost for the OFA during operation as there are no reagents involved.

4) Selective Non-Catalytic Reduction

SNCR is a post-combustion technology that injects anhydrous ammonia, aqueous ammonia, or aqueous urea into the flue gas within a temperature range of 1600^{o}F- 2100^{o}F. In this temperature range, the ammonia reacts with nitrogen oxide in the presence of oxygen to form nitrogen and water.

Multiple injection levels can be used to follow the optimum gas temperature through the boiler and thereby maintain high nitrogen oxide reduction efficiencies as the boiler load changes. Placement of the injection probes is critical because at flue gas temperatures above 2100ºF, ammonia and urea react with oxygen to form additional nitrogen oxide. Excess ammonia at temperatures below 1600ºF lead to formation of ammonium salts which can plug air heater baskets and contaminate fly ash to the point of being unsalable and objectionable to handle due to its strong odor. The ammonia concentration leaving the boiler is generally controlled to about 5 ppm.

SNCR is applicable to all of the MidAmerican coal-fueled units that do not have Selective Catalytic Reduction ("SCR") installed. While historically this technology was generally only applicable for units 300 megawatts and smaller, more robust modeling techniques have allowed the technology to be proven on units up to 750 megawatts with limited ammonia slip. A 20% to 30% reduction in nitrogen oxide emissions is typical for SNCR systems; however, the outlet nitrogen oxide from the system is typically no lower than 0.15 lb/mmBtu due to chemical limitations. SNCR installations typically have installed capital costs that are less than 25% of SCR installations at coal-fueled facilities.

The operations and maintenance costs for this control are comprised of urea liquid reagent and equipment maintenance. The urea reagent costs are the majority of cost associated with SNCR operation. A smaller cost amount is needed for maintenance of pumps, controls, injection systems, etc. for the SNCR equipment.

5) Activated Carbon Injection

The ACI process removes gaseous elemental and oxidized mercury compounds by injecting porous powdered carbon into the flue gas. The mercury adsorbs on the surface of the porous carbon and is collected. ACI is best used in a dry system where the particulate collection device is a baghouse. A baghouse is preferred because carbon is not as effectively collected in an electrostatic precipitator, nor does it provide the same level of control.

Activated carbon has been shown to remove up to 90% of the mercury in a flue gas stream when used in conjunction with a baghouse. In most instances, the halogenated carbons appeared to be more effective in collecting mercury at lower injection concentrations than the plain carbons. MidAmerican utilizes halogenated carbon in the ACI system at WSEC Unit 4 for mercury control and has installed ACI at each coal-fueled generating station that uses a baghouse for particulate control to comply with the MATS. MidAmerican also supplements the halogen in the carbon with additional halogen as needed; the halogen oxidizes the mercury and allows the carbon to remove it more efficiently.

The adsorption of mercury by activated carbon is strongly dependent upon the temperature of the flue gas. Field-testing has indicated a dramatic decrease in the removal of mercury at gas temperatures above 300ºF. The target temperature is in the range of 160ºF to 250ºF. The flue gas temperature following a dry scrubber and baghouse installation is typically 160ºF, making it optimal for this type of mercury control. Additionally, the activated carbon which collects on the baghouse filter bags aids in further collecting mercury since the flue gas must pass through this carbon dust layer before exiting the system.

The operations and maintenance costs for this control is comprised of activated carbon sorbent, supplemental oxidation chemical such as calcium bromide, and maintenance for the ACI system equipment. [redacted]

6) Turbine Efficiency Upgrades

With the U.S. Environmental Protection Agency's regulations relating to GHG emissions, PSD permitting requirements now also include an analysis of all the emission controls available to a facility for controlling each applicable pollutant. The outcome of this analysis is selection of BACT. The available controls for GHG emissions from a power plant include such items as carbon capture and sequestration, thermodynamic cycle design, fuel selection, and plant efficiency improvements. For the Neal Unit 3 and Neal Unit 4 projects, GHG BACT was found by Iowa Department of Natural Resources ("Iowa DNR") to be efficiency improvement projects including the installation of higher efficiency steam turbine sections. More efficient turbines or turbine sections directly improve overall plant heat rate, requiring less fuel per megawatt output.

Turbine upgrades can vary from plant to plant and can include partial upgrades of turbines or entire new turbine assemblies. The Air Quality Construction Permits received by MidAmerican from the Iowa DNR for the Neal Unit 3 and Neal Unit 4 emission control projects require certain levels of turbine efficiency improvements as well as caps on total carbon dioxide emissions. In general, the heat rate improvement from turbine efficiency upgrades is dependent upon the original design of the turbine or turbine section being upgraded and physical limitations of other supporting equipment.

Typical heat rate improvements from turbine efficiency projects can range from 1% to 3%, or an improvement of 100 to 330 Btu/kWh, at most facilities. These heat rate improvements can generally offset the heat rate degradation associated with the additional plant auxiliary power required to operate dry scrubber and baghouses used to control sulfur dioxide emissions.

No operations and maintenance costs are assumed specifically for this control as there are no reagents. Maintenance for the turbine is required during scheduled outages but would be required whether the efficiency upgrades were made or not.

D. MIDAMERICAN'S 2020 BUDGET SUPPORTING DETAIL

The following table includes a summary of MidAmerican's existing operated coal-fueled plants, along with generating capacity and MidAmerican ownership. Although information for WSEC Unit 4 is provided, no emission controls or associated funding is being requested as part of the 2020 Update.

Summary of MidAmerican's Operated Coal-Fueled Plants
Generating Capacity and Percent Ownership

Unit	Net Capacity (MW)	MidAmerican Ownership
Neal Unit 3	510	72.00%
Neal Unit 4	644	40.57%
Louisa	745	88.00%
WSEC Unit 3	690	79.10%
WSEC Unit 4	800	59.66%

The following pages show the specific details of the 2020 Update covering the controls at MidAmerican's coal-fueled generating units for the period January 1, 2020 through December 31, 2022.

1) WSEC Unit 3

[redacted]

Controls at WSEC UNIT 3 – 2020 through 2022

	NO_x Emissions (lb/mmBtu)	SO2 Emissions (lb/mmBtu)	Hg Emissions (lb/TBtu)	CO2 Emissions (lb/MWh)	Totals
2019 Actual	0.20	0.36	0.41	2,275	N/A
Increase in Heat Rate (Btu/kWH)	[redacted]				
Decrease in Output (MWs)					
Capital Cost (2020-2022)					
Fixed O&M Cost (2020 $/Year)					
Var. O&M Cost (2020 $/MWH)					

2) Louisa

[redacted]

Controls at Louisa – 2020 through 2022

	NO_x Emissions (lb/mmBtu)	SO2 Emissions (lb/mmBtu)	Hg Emissions (lb/TBtu)	CO2 Emissions (lb/MWh)	Totals
2019 Actual	0.17	0.31	0.31	2,166	N/A
Increase in Heat Rate (Btu/kWH)	[redacted]				
Decrease in Output (MWs)	[redacted]				
Capital Cost (2020-2022)	[redacted]				
Fixed O&M Cost (2020 $/Year)	[redacted]				
Var. O&M Cost (2020 $/MWH)	[redacted]				

3) Neal Unit 3

[redacted]

Controls at Neal Unit 3 – 2020 through 2022

	NO_x Emissions (lb/mmBtu)	SO2 Emissions (lb/mmBtu)	Hg Emissions (lb/TBtu)	CO2 Emissions (lb/MWh)	Totals
2019 Actual Emissions	0.20	0.35	0.18	2,319	N/A
Increase in Heat Rate (Btu/kWH)	[redacted]				
Decrease in Output (MWs)					
Capital Cost (2020-2022)					
Fixed O&M Cost (2020 $/Year)					
Var. O&M Cost (2020 $/MWH)					

4) Neal Unit 4

[redacted]

Controls at Neal Unit 4 – 2020 through 2022

	NO_x Emissions (lb/mmBtu)	SO2 Emissions (lb/mmBtu)	Hg Emissions (lb/TBtu)	CO2 Emissions (lb/MWh)	Totals
2019 Actual Emissions	0.17	0.34	0.36	2,058	N/A
Increase in Heat Rate (Btu/kWH)	[redacted]				
Decrease in Output (MWs)					
Capital Cost (2020-2022)					
Fixed O&M Cost (2020 $/Year)					
Var. O&M Cost (2020 $/MWH)					

It is the responsibility of Interstate Power and Light Company, as plant operator of the OGS, to plan, schedule, and install controls at this facility. As such, MidAmerican has not included any plans by Interstate Power and Light Company to install environmental controls at OGS as part of the 2020 Environmental Plan and Budget Update approval period through 2022.

E. EQUIPMENT BIDDING AND INSTALLATION STRATEGY

If necessary, MidAmerican would install future emission control equipment (as applicable) by following its competitive bidding process and completing the installations during the units' regularly scheduled outages.

F. OTHER PLAN CONSIDERATIONS

Development of the 2020 Environmental Plan and Budget Update also considered economic development potential, and the reliability of the electric generation and transmission system.

1) Economic Development

By reducing emissions, the air emission increment available for other industrial developments increased. More importantly, emission reductions maximize the opportunity for Iowa to avoid non-attainment status. Non-attainment status can be a significant economic development detriment. MidAmerican's implementation strategy occurred across the state, resulting in air quality benefits in all areas.

2) Transmission System Reliability

[redacted]

[redacted]

3) Generation System Reliability

[redacted]

[redacted]

II. SUMMARY OF 2020 BUDGET UPDATE

Environmental Plan and Budget Confidential Exhibit 1 (Capital Investments) and Environmental Plan and Budget Confidential Exhibit 2 (O&M Expenses) summarize MidAmerican's 2020 Budget Update for the coal-fueled generating stations.