Benefits of the Otter Tail Power Project

Power Plant Improvement Initiative

Demonstration of an Advanced Hybrid Particulate Collector

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Executive Summary

- **Demonstration projects are critical to successful commercialization of technology developed under DOE's Fossil Energy R&D program.**
- **Successful commercial application of the Advanced Hybrid Particulate Collector in the United States would significantly reduce emissions.**
  - 52,580 tons per year of Total Particulate Matter
  - 35,670 tons per year of PM_{10}
  - 16,230 tons per year of $PM_{2.5}$
  - 202,700 tons per year of SO_2
- **Up to $750 million would be saved by power companies installing the equipment needed to achieve these low emissions.**

Outline

- **Description of the Advanced Hybrid Particulate Collector.**
- **Quantitative estimates of the benefits of the Otter Tail Power project.**
  - Benefits to the Nation
  - Benefits to Otter Tail Power's Big Stone plant
- **Approach used to calculate benefits.**

Otter Tail Power Project

- A 450 MW_e demonstration of Advanced Hybrid Particulate Collector (AHPC) technology.
- Installed on a cyclone boiler firing coal from Wyoming's Powder River Basin at Otter Tail Power's Big Stone Power Plant, Big Stone City, SD.

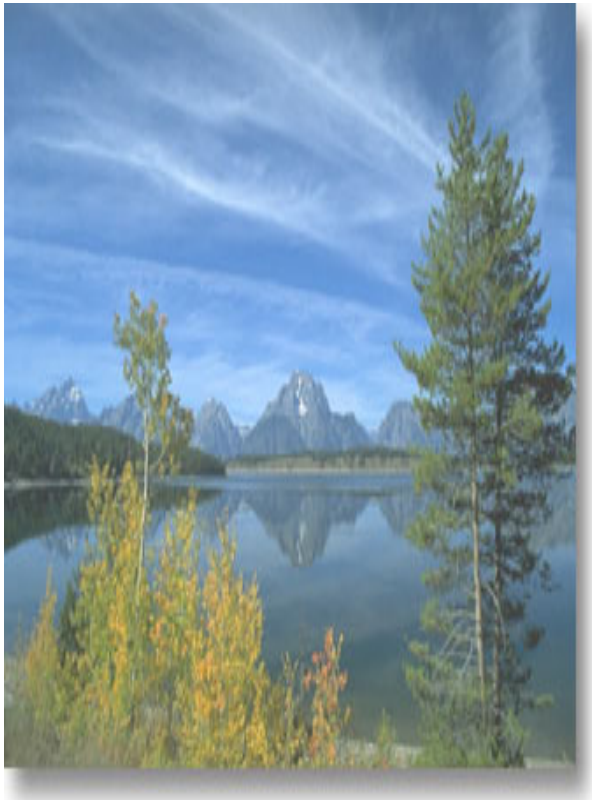
Big Stone Power Plant

AHPC Installed at Otter Tail Power's Big Stone Plant

Advanced Hybrid Particulate Collector

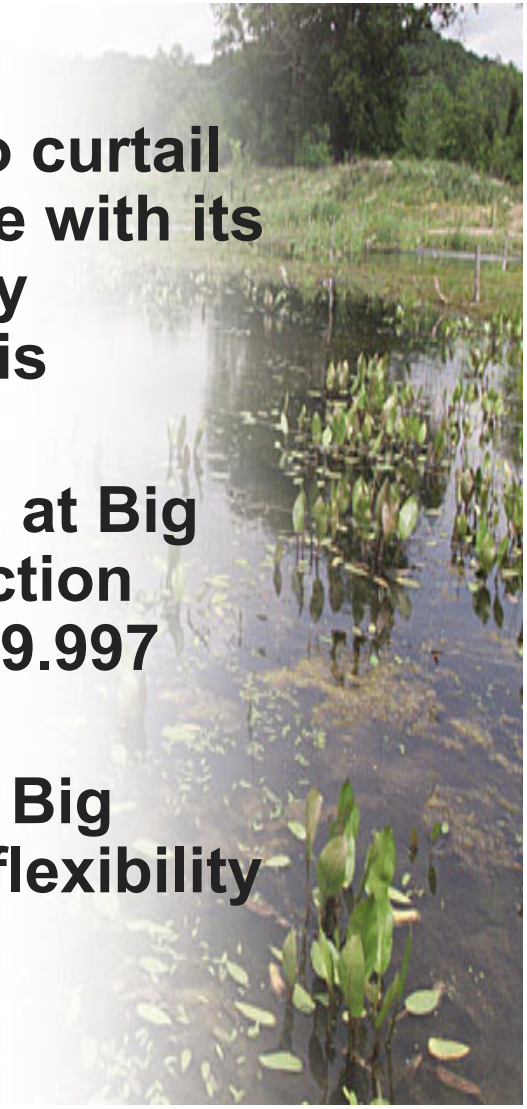
- A highly efficient particulate control device with membrane filter bags interspersed with perforated electrostatic precipitator (ESP) plates and electrodes in the same housing.
- Will reduce emissions of airborne particles to less than 0.007 pounds per million Btu – more than four times cleaner than required by current clean air laws.
- Forecast to be installed on 25 GW_e of existing coal-fired capacity.

Advantages of AHPC



- The membrane filter bags can achieve greater collection of very fine particles than can the ESP plates, while the ESP plates can capture dust that is re-entrained due to back pulsing of the membrane filter bags.
- Almost complete capture of fine particulate matter.
- Allows switching to low-sulfur coal.
- Eliminates need to de-rate existing power plants to meet opacity requirements.

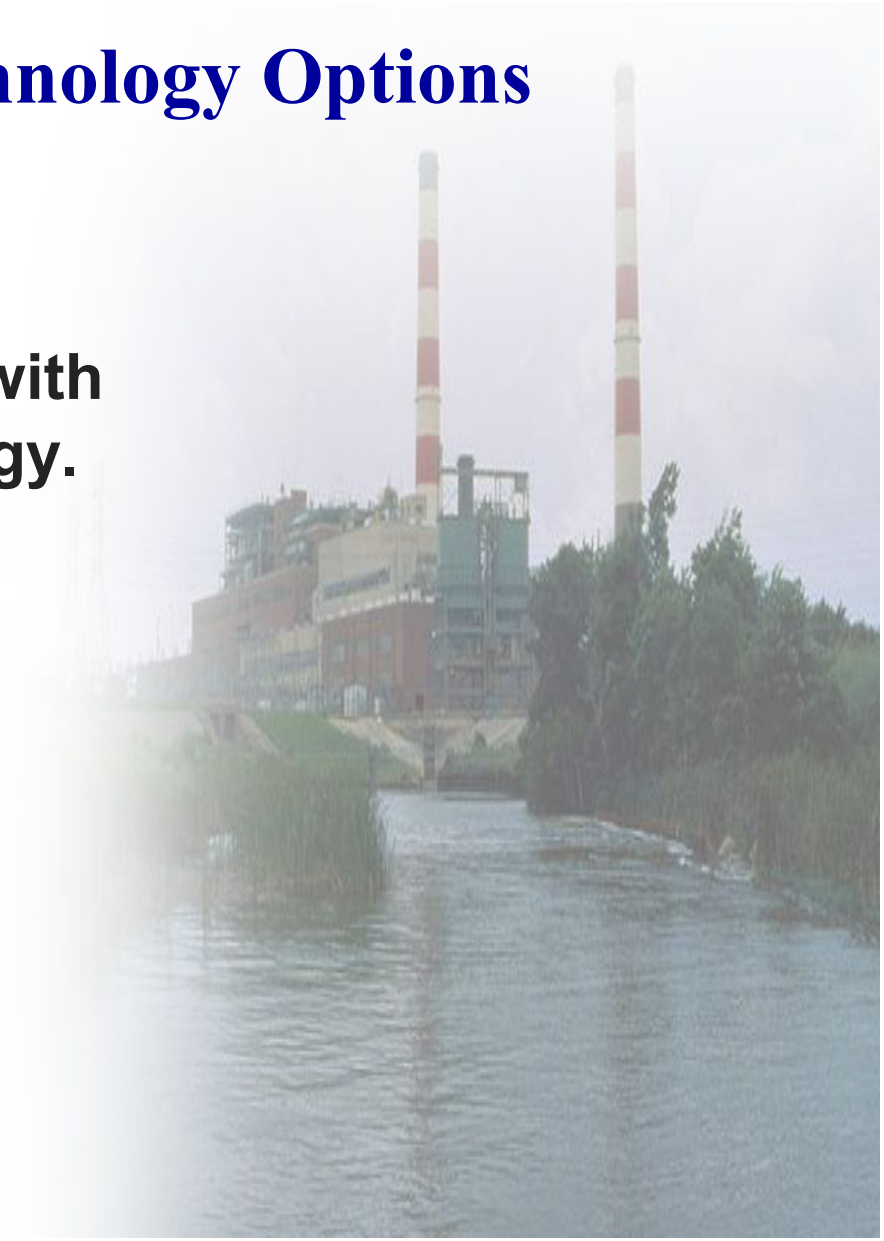
Performance of AHPC at Big Stone



- Big Stone Plant had been forced to curtail operations to remain in compliance with its opacity limit of 20 percent. Opacity following installation of the AHPC is typically 1 percent.
- Recent emissions tests conducted at Big Stone show that the average collection efficiency of the AHPC system is 99.997 percent.
- Installation of the AHPC system at Big Stone provides much greater fuel flexibility to the plant operators.

Competing Technology Options

- **Renovate existing ESP**
- **Replace existing ESP with conventional technology.**
  - Fabric filters
  - Wet ESP
- **Apply other advanced technology options.**
  - COHPAC



Estimated Reductions in National Pollution Emissions from AHPC Commercialization

	AHPC Emission Reductions, tons/year	All Boiler Emissions, tons/year
Total Particulate Matter	**52,580**	**522,400**
PM_{10}	**35,670**	**360,900**
$PM_{2.5}$	**16,230**	**167,100**
SO_2 Basis: AHPC technology would facilitate 4.7 GW_e of generating capacity to switch to low sulfur coal.	**202,700**	**10,770,000**

Note: PM_{10} and $PM_{2.5}$ emissions were estimated using generalized emissions factors.

Additional National Benefits from AHPC Commercialization

- AHPC technology could save up to $750 million in capital costs when compared to the installation of conventional fabric filter systems to achieve the same low particulate emissions on 25 GW_e of existing power plants.

Benefits of AHPC for Big Stone

	Total Particulate Emissions, tons/year
Before Retrofit	360
After Retrofit	130
Emissions Avoided	230

Total particulate emissions at the Big Stone power plant are estimated to decrease by at least 65% due to the installation of AHPC technology

Additional Benefits of AHPC for Big Stone

- AHPC technology is estimated to save up to $13.5 million in capital costs when compared to the installation of a conventional fabric filter system to achieve the same low particulate emissions at the Big Stone power plant.

Approach to Estimating Benefits

- **Forecast market penetration.**
- **Quantify differences between performance of conventional technology and the anticipated performance of the Advanced Hybrid Particulate Collector being demonstrated.**
  - Pollutant emissions, tons per year
  - Capital cost, constant dollars

Assumed Market Penetration

- **Individual boilers most likely to install AHPC were selected from the NETL Coal Power Data Base.**
- **These target boilers were selected based on specific attributes that made them most likely to benefit from AHPC technology.**
  - Equipped with pollution control equipment that includes a cold-side ESP but not an SO_2 scrubber
  - Capacity factor of at least 0.80
  - ESP in-service date of 1982 or before
  - Boilers that came on line after 1962
- **25,614 MW_e of existing power plants selected.**

Differences in Performance
- Total Particulate Matter -

- **Total particulate matter currently emitted by individual boilers most likely to install AHPC was calculated using the NETL Coal Power Data Base.**
  - Typical particulate matter emissions for the year 2000 reported to EIA (Form 767)
- **Emissions of total particulate matter after installation of AHPC were estimated by multiplying the annual thermal input to each plant by the expected performance of the AHPC (0.007 pounds per million Btu).**
  - Operating information for the year 2000 reported to EIA (Form 767)

Differences in Performance
- Fine Particulate Matter -

- **Fine particulate matter currently emitted by individual boilers most likely to install AHPC was calculated using the NETL Coal Power Data Base.**
  - Employed generalized emissions factors (AP42) and the fraction of total particulate matter emitted as both PM_{10} and $PM_{2.5}$
- **Emissions of fine particulate matter after installation of AHPC were estimated using a ratio of fine particulate matter to total particulate matter calculated for each boiler.**

Differences in Performance
- Fuel Flexibility -

- **Boilers equipped with ESP's have limited fuel flexibility.**
  - Differences in fly ash resistivity can increase flue gas opacity causing boiler operations to be curtailed
- **Individual boilers that could cost effectively switch to Powder River Basin (PRB) low-sulfur coal if equipped with AHPC were identified using data from a paper by Dennis Smith and Shreekant Malvadkar (NETL) titled, "Supply Curves for Sulfur Emission Costs for Power Plants using Powder River Basin Coal to Meet President Bush's Clear Skies Initiative."**

Differences in SO_2 Emissions

- Boilers installing AHPC that could also switch to PRB coal at a cost of no more than $290 per ton of SO_2 avoided were assumed to reduce their emissions rate to 0.35 pounds of sulfur per million Btu.
- Sulfur emissions after switching to PRB coal were estimated by multiplying the annual thermal input to each plant by 0.35 pounds per million Btu.

Differences in Capital Cost

- **For this analysis, the capital cost to install AHPC technology at an existing power plant is estimated to be $40 per kW.**
  - Actual installation cost at Big Stone was lower
- **The capital cost of installing a conventional fabric filter capable of achieving the same level of performance as the AHPC (emissions of airborne particles less than 0.007 pounds per million Btu) is estimated to be $70 per kW.**
  - Based on engineering judgment
- **The cost savings associated with AHPC technology is the difference between these costs multiplied by the assumed market penetration (25 GW_e of existing coal-fired capacity).**

Conclusions

- **There are significant benefits to the nation that will be realized by the commercialization of technologies being demonstrated in the Power Plant Improvement and Clean Coal Power Initiatives.**

Visit the NETL web site for information on all Power Plant Improvement Initiative and Clean Coal Power Initiative projects.

www.netl.doe.gov/coalpower/ccpi