ATTACHMENT NO. 3

Response to WDEQ's Completeness Review Dated December 21, 2005

WDEQ Comment 3: *Basin Electric proposed fabric filters with an emission limit of 0.012 lb/MMBtu, 3-hour average. An analysis of the technical feasibility and cost effectiveness is required for emission levels of 0.009, 0.01, and 0.011 lb/MMBtu, 3-hour average.*

Response: In the Permit Application, BEPC evaluated the potential feasibility of both electrostatic precipitation (ESP) control systems and fabric filter baghouse systems. Based on a technical review of each particulate matter (PM) control system, and BACT emission limits included in recently issued PSD permits for coal-fired power plants, BEPC concluded that the fabric filter baghouse represented the most effective PM_{10} control device, and proposed a controlled PM_{10} (filterable) emission rate of 0.012 lb/mmBtu (3-hour average).

Fabric filtration has been widely applied to coal combustion sources since the early 1970s and consists of a number of filtering elements (bags) along with a bag cleaning system contained in a main shell structure incorporating dust hoppers. Fabric filters use fabric bags as filters to collect particulate matter. The particulate-laden gas enters a fabric filter compartment and passes through a layer of filter bags. The collected particulate forms a cake on the bag that enhances the bag's filtering efficiency. Excessive caking will increase the pressure drop across the fabric filter at which point the filters must be cleaned.

The particulate removal efficiency of fabric filters is dependent upon a variety of particle and operational characteristics. Particle characteristics that affect the collection efficiency include particle size distribution, particle cohesion characteristics, and particle electrical resistivity. Operational parameters that may affect fabric filter collection efficiency include bag material, air-to-cloth ratio, and operating pressure loss.

Fabric-filters have relatively constant outlet emissions while exhibiting varying pressure drops dependent upon the degree of cake thickness. As the flue gas passes through the fabric, the captured particulate forms a cake on the surface of the fabric. This deposit increases both the filtration efficiency and its resistance to gas flow. Therefore, for continuous operation, a fabric-filter must have some mechanism for periodic cleaning of the deposited cake. Cleaning mechanisms include reverse-air systems and pulse-jet systems. The cleaning mechanism is frequently used to describe the type of fabric filter. BEPC proposed a pulse jet baghouse following the dry flue gas desulfurization system for Dry Fork Unit 1.

Fabric specifications include such properties as tensile strength, abrasion resistance, chemical attack resistance and limitations of operating temperature. Synthetic fibers are typically used because they can operate at higher temperatures and more effectively resist chemical attack. The synthetic fiber most used for high temperature applications (i.e., 400 °F to 500 °F) is fiberglass. For low temperature applications below approximately 200 °F, such as dry FGD systems and coal crushers, polypropylene is often used. For power plant applications, with typical air heater outlet temperatures around 300 °F, other registered trademark fibers such as Teflon, Fiberglas, Ryton, and P84 have also been used. Most of the baghouses currently operating on coal fired utility boilers use bags made with Fiberglas or Ryton. Ryton is a felted filter made of polyphenylene sulfide fibers generally attached to a polyfluorocarbon scrim. Ryton can operate at continuous temperatures of 370 °F or less, and shows good resistance to acids and alkalis. Fiberglas, Teflon, Nomex and Ryton have been used to remove particulate emissions generated from industrial and utility coal-fired boilers. Another material used to make bags is Gore-tex membrane. The Gore-tex membrane is an expanded polytetrafluoroethylene (PTFE) membrane that is laminated with a variety of fibers such as Fiberglas to produce felt and woven filters. Pulse-jet baghouse vendors typically specify either PPS or P84 bag material. Other fabric materials may not be suitable because of the more aggressive cleaning system associated with a pulse-jet baghouse.

Overall fabric filter system designs involve the selection of the cleaning mechanism and type of fabric to be used for a particular service. When assessing emission control limits of fabric filters, the issue of mechanical integrity of the filter housing (e.g., welds, seams, bag hangers, and connections) may become just as important as the filter fabric. As specialty fabrics reduce the flow or particulates through the fabric, the relative importance of particulate emissions due to compromises in the integrity of the filter housing (e.g., failed welds, cracks, loose bag hangers, etc) becomes more pronounced.

Based on engineering experience, it is expected that a properly sized and operated fabric filter should consistently achieve a filterable PM_{10} emission rate below 0.015 lb/mmBtu, and may achieve actual emission rates in the range of 0.010 lb/mmBtu. However, because of the potential for increased particulate emissions immediately following a cleaning cycle (i.e., before the filter cake is re-established), and because of the potential for particulate emissions associated with filter housing integrity, fabric filter vendors have not provided guarantees below 0.012 lb/mmBtu. Based on recent coal-fired boiler projects, the most stringent guaranteed PM_{10} emission rate available is in the range of 0.012 lb/mmBtu. Furthermore, to guarantee an emission rate below approximately 0.012 lb/mmBtu, it is likely that the fabric filter vendors will specify the use of specialty filter bags such as PTFE membrane bags. These specialty bags are more expensive but should provide slightly higher control efficiencies. Between controlled emission rates of 0.015 and 0.012 lb/mmBtu it appears that several commercially available fabrics could be used successfully to ensure compliance.

This evaluation is based on the following assumptions: (1) guarantees for a controlled emission rate below 0.010 lb/mmBtu are not currently available; (2) controlled emission rates of 0.010 and 0.011 lb/mmBtu would be technically feasible, however, to ensure compliance with these emission rates the baghouse vendor would specify specialty membrane filter bags; and (3) controlled emission rates between 0.012 and 0.015 lb/mmBtu are technically feasible, and compliance with these emission rates could be achieved using a variety of commercially available fabrics.

Summarized in Table 1 are the maximum annual PM_{10} mass emissions associated with each technically feasible PM_{10} emission rate. Table 2 presents the capital costs and annual operating costs associated with building and operating each fabric filter control system. Table 3 shows the average annual cost effectiveness and incremental cost effectiveness of the fabric filter control systems.

Table 1
Annual PM_{10} Emissions

Control Technology	**PM_{10} Emissions (lb/mmBtu)**	**Maximum Annual Emissions (tpy)***	**Annual Emission Reductions (tpy from base case)***
Fabric Filter @ 0.009 lb/mmBtu	0.009	NA (emission rate not commercially available)	NA (emission rate not commercially available)
Fabric Filter @ 0.010 lb/mmBtu (Specialty membrane bags)	0.010	166	31,743
Fabric Filter @ 0.011 lb/mmBtu (Specialty membrane bags)	0.011	183	31,726
Fabric Filter @ 0.012 lb/mmBtu (Ryton or equivalent bags)	0.012	200	31,709
Fabric Filter @ 0.013 lb/mmBtu (Ryton or equivalent bags)	0.013	216	31,693
Fabric Filter @ 0.014 lb/mmBtu (Ryton or equivalent bags)	0.014	233	31,676
Baseline Emissions** (No Control)	1.92	31,909	-

* Maximum annual emissions, and annual emission reductions were calculated based on a maximum heat input to the boiler of 3,801 mmBtu/hr and 100% capacity factor.

** Baseline PM_{10} emissions were calculated based on the following assumptions: (1) maximum heat input to the boiler of 3,801 mmBtu/hr; (2) fuel heating value of 7,800 Btu/lb; (3) maximum ash content of 6.5%; (4) 80:20 split between fly ash and bottom ash; and (5) 23% of the potential PM emissions were PM_{10} (AP-42 Table 1.1-6).

Table 2
PM_{10} Emission Control System
Cost Summary

Control Technology	Total Capital Investment ($)	Total Capital Investment ($/kW-net)	Annual Capital Recovery Cost ($/year)	Annual Operating Costs ($/year)	Total Annual Costs ($/year)
Fabric Filter @ 0.010 lb/mmBtu (Specialty membrane bags)	$40,811,390	$106.0	$3,852,300	$3,410,500	$7,262,800
Fabric Filter @ 0.011 lb/mmBtu (Specialty membrane bags)	$40,719,990	$105.8	$3,843,700	$3,247,400	$7,091,100
Fabric Filter @ 0.012 lb/mmBtu (Ryton or equivalent bags)	$38,372,990	$99.7	$3,622,100	$2,594,500	$6,216,600
Fabric Filter @ 0.013 lb/mmBtu (Ryton or equivalent bags)	$38,281,490	$99.4	$3,613,500	$2,536,400	$6,149,900
Fabric Filter @ 0.014 lb/mmBtu (Ryton or equivalent bags)	$38,194,590	$99.2	$3,605,300	$2,476,100	$6,081,400
Baseline Emissions** (No Control)					

Table 3
PM_{10} Emission Control System
Cost Effectiveness

Control Technology	Total Annual Cost ($/year)	Annual Emission Reduction (tpy)	Average Annual Cost Effectiveness ($/ton)	Incremental Annual Cost Effectiveness* ($/ton)
Fabric Filter @ 0.010 lb/mmBtu (Specialty membrane bags)	$7,262,800	31,743	$229	$10,100
Fabric Filter @ 0.011 lb/mmBtu (Specialty membrane bags)	$7,091,100	31,726	$224	$51,441
Fabric Filter @ 0.012 lb/mmBtu (Ryton or equivalent bags)	$6,216,600	31,709	$196	$4,169
Fabric Filter @ 0.013 lb/mmBtu (Ryton or equivalent bags)	$6,149,900	31,693	$194	$4,029
Fabric Filter @ 0.014 lb/mmBtu (Ryton or equivalent bags)	$6,081,400	31,676	$192	--

* Incremental cost effectiveness was calculated by comparing each control technology with the next most stringent control technology, and dividing the incremental increase in the Total Annual Cost by the incremental decrease in annual PM10 emissions.

The average cost effectiveness of the fabric filter system varies between approximately $192/ton and $229/ton. The average cost effectiveness is low because of the large quantity of particulate matter removed by the system (greater than 31,500 tons per year).. Because all of the potentially feasible fabric filter control systems remove large quantities of particulate matter, it is appropriate to evaluate the incremental cost effectiveness of the fabric filter systems designed to achieve more stringent emission limits.[1]

The incremental cost associated with reducing controlled PM_{10} emissions from 0.014 to 0.013 lb/mmBtu and from 0.013 to 0.012 lb/mmBtu is estimated to be approximately $4,029 and $4,169/ton, respectively. These costs are significantly higher than the average cost of PM_{10} control at Dry Fork Unit 1, but would not create a significant economic impact because of the relatively small reduction in annual PM_{10} emissions (approximately 17 tons/year). Costs associated with the more stringent PM_{10} emission rates would include a small increase in initial capital cost and a small increase in annual O&M costs.

Below a permit limit of approximately 0.012 lb/mmBtu, it is anticipated that fabric filter vendors would specify the use of specialty bags. Specialty bags represent a significant increase in the initial capital investment and a significant increase in the cost of replacement bags. Assuming specialty bags would be specified, the incremental cost effectiveness associated with reducing PM_{10} emissions from 0.012 to 0.011 lb/mmBtu is estimated to be approximately $51,441/ton. This incremental cost effectiveness is disproportionately high because of the relatively small increase in emission reductions (approximately 17 tpy) and the relatively large increase in initial capital and O&M costs associated with the specialty bags. The incremental cost effectiveness associated with the more stringent PM_{10} emission limits should preclude specialty bags from consideration as BACT.

Based on technical feasibility, physical limitations of the control system, guaranteed emission rates available from control system vendors, and economic impacts, BEPC is proposing an emission rate of 0.012 lb/mmBtu (3-hour average) as BACT for filterable PM_{10} control.

In addition to potential economic impacts, there may be collateral environmental impacts associated with the membrane filters. The effectiveness of a bag filter increases as the particulate cake builds on the fabric and within the interstitial space of the filtering material. In addition to increasing the filtering effectiveness, the alkaline filter cake captures SO_2, acid gases, and trace constituents including mercury. Once the pressure drop across the filter cake reaches a certain level, the bag is cleaned and the filtering/cake building process starts over. Membrane fabrics will release virtually all of the filter cake during the cleaning cycle, and may not retain a particulate cake within the

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[1] See, NSR Review Manual: "In addition to the average cost effectiveness of a control option, incremental cost effectiveness between dominant control options should also be calculated. The incremental cost effectiveness should be examined in combination with the average cost effectiveness in order to justify elimination of a control system." page B.41. "A comparison of incremental costs can be useful in evaluating a specific control option over a range of efficiencies. For example, depending on the capital and operational costs of a control device, total and incremental cost may vary significantly (either increasing or decreasing) over the operation range of a control device." page B.43.

fabric's interstitial space after cleaning. This characteristic of a membrane filter may inadvertently reduce the unit's overall control efficiency of acid gases and mercury.

All recently permitted PC boilers have been permitted with fabric filters as BACT for PM_{10} control. The lowest filterable PM_{10} emission rate designated as BACT is 0.012 lb/mmBtu at Comanche Unit 3 (Colorado) and Wygen Unit 2 (Wyoming). Neither unit has commenced operation or demonstrated the ability to achieve the proposed BACT emission limit on an on-going long-term basis. Several other facilities, including Roundup Units 1 and 2 (Montana) and Intermountain Unit 3 (Utah), have been permitted with a filterable PM_{10} emission rate of 0.015 lb/mmBtu. Because BPEC is proposing a control technology that results in the most stringent controlled emission rate, the use of fabric filters and a controlled PM_{10} emission rate of 0.012 lb/mmBtu should be considered BACT for the proposed boiler.