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ENERGY WATER INFORMATION GOVERNMENT

Big Stone II Co-Owners
Big Stone II Power Plant

B&V Project 142662
B&V File 42.2600
BVC/BSP-014a
March 27, 2007

Big Stone Plant
48450 144th Street
P. O. Box 218
Big Stone City, SD 57216-0218

Subject: Heat Rejection Technology Assessment

Attention: Mr. Mark Rolfes
Project Manager

Gentlemen:

As requested, Black & Veatch has prepared a Heat Rejection Technology Assessment as a followup document to the March 18, 2005 600 MW Plant Cooling System Evaluation document prepared by Burns & McDonnell and distributed to Black & Veatch by the project team on September 16, 2006.

During the project conceptual design and optimization effort, it was discovered that major conceptual changes could be made that maximized unit efficiency and minimized overall cost while, at the same time, reducing surface water evaporation and providing the drought tolerance needed for the facility.

Surface Water Drought Tolerance

Big Stone power station drought tolerance water supply was originally conceived to be provided from on-site water storage ponds. These ponds were designed to provide sufficient water storage for up to one year of water consumption by the plant in the event that water from Big Stone Lake was not available to the station. In order to accomplish this, it was proposed to construct a new 450 acre BSP II makeup water pond and to convert the existing BSP I wastewater evaporation and holding ponds to fresh water storage.

Under the original plan, water from Big Stone Lake was pumped to the three on-site storage ponds (BSP I wastewater evaporation pond, BSP I holding pond, and BSP II makeup water pond). Fresh water in these three ponds was then pumped to the BSP I cooling pond as makeup water for losses due to evaporation from the pond, and water was supplied from the BSP I cooling pond to the BSP II cooling tower as makeup. Water losses from the BSP II cooling tower include evaporation and blowdown. Blowdown from the cooling tower is routed to a cooling tower blowdown pond where a portion of this water was reused as makeup to the flue gas desulfurization (FGD) system. Excess cooling tower blowdown was combined with purge water from the FGD and routed to the wastewater treatment system. The wastewater treatment system consisted of the existing BSP I brine concentrator and a new BSP II brine concentrator/crystallizer to handle the additional wastewater created by the new plant. Here the wastewater was treated to produce a high purity distillate and a landfillable solid. A portion of the high purity distillate was further treated for makeup to the BSP I and BSP II boilers and the remainder was exported to the adjacent ethanol plant resulting in a zero liquid discharge (ZLD) design.

Ground Water Drought Tolerance

Ground water drought tolerance was conceived as a method to reduce dependence on surface water storage. Under this plan, BSP II utilizes ground water as makeup to the plant in the event that Big Stone Lake water is not available. Due to differences in the water chemistry constituents in the ground water versus the lake water, a different water management plan is required.

Under normal conditions, water from Big Stone Lake is pumped to the BSP I cooling pond as makeup. Makeup water for the BSP II cooling tower is taken from the BSP I cooling pond. However in this scenario, the makeup water is pretreated in a lime/soda softening process to reduce the scaling potential of the makeup water and ultimately reduce the BSP II cooling tower blowdown. This softening process is required in order to efficiently utilize the ground water and is also used with lake water makeup to optimize water consumption of the plant. Groundwater is routed directly to the pretreatment system when required. The softening process is based on precipitation of the scaling constituents in the water (primarily hardness and silica) and is achieved by adding lime, soda ash, coagulant (Alum) and polymer to produce a settleable solid. The solids produced in the process have a beneficial use in the power plant as reagent in the FGD system. These solids are pumped from the pretreatment system to the FGD process. Purge stream wastewater from the FGD system is first routed to an 8 acre lined pond for settling of suspended solids and then on to a new 70 acre lined FGD evaporation pond designed to naturally evaporate the wastewater. This new FGD evaporation pond will be constructed by lining 70 acres of the existing BSPI evaporation pond.

Demineralized water for BSP I and BSP II consumption is produced by a new high purity water treatment system fed from the new pretreatment system. Softened cooling pond water is fed to a new reverse osmosis (RO) unit designed to remove approximately 98 percent of the dissolved salts. Additional reduction of dissolved salts occurs in a mixed bed ion exchange unit (new for BSP II, existing for BSP I) following the RO to make water suitable for makeup to the steam cycle. The RO reject stream is routed back to the cooling pond for reuse. The neutralized regenerant wastewater from the mixed bed unit is also routed back to the cooling pond for reuse.

Under the groundwater drought tolerance scenario, the Big Stone Power Plant remains a ZLD facility by balancing the wastewater production with wastewater reuse. The existing holding pond, a portion of the existing evaporation pond, and the existing brine concentrator remain as wastewater treatment facilities in the event this becomes necessary. However, this is not anticipated.

Heat Rejection Technology Assessment

The Heat Rejection Technology Assessment analyzed the following four options:

1. Wet cooling with surface water supply and makeup water storage pond
2. Wet cooling with surface water primary supply and groundwater supply backup
3. Wet/dry (hybrid) cooling with surface water primary supply and groundwater supply backup
4. Dry cooling with surface water primary supply and groundwater supply backup

Each of the options indicated above requires different water treatment system designs. All four options produce identical net plant outputs on the hot ambient day. The scope of each option is identified below:

Option 1 - Wet Cooling with Surface Water Supply and Makeup Water Storage Pond

This Option retains the originally conceived surface water management plan and couples it with traditional wet cooling technology. Option 1 requires a significant cost be applied to the project for the wastewater treatment systems. Additionally, there is a significant energy loss needed to evaporate the wastewater stream.

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Option 2 – Wet Cooling with Surface Water Supply and Groundwater Supply

Option 2 utilizes groundwater supply as a drought tolerance provider while retaining the original wet cooling system. However, the chemical treatment systems are changed to treat the makeup water rather than the wastewater as described above. The resulting capital costs are reduced and overall plant performance is increased.

Option 3 – Hybrid Cooling with Surface Water Supply and Groundwater Supply

Option 3 is a combined wet/dry system designed to provide complete heat rejection via dry cooling during the annual average ambient conditions. The wet portion of the system is utilized in parallel to the dry system as needed to achieve full unit output on warmer days. The makeup water pretreatment system is utilized as described above. However, the pretreatment equipment sizing can be reduced due to the reduction in water losses.

Option 4 – Dry Cooling with Surface Water Supply and Groundwater Supply

Option 4 utilizes an air cooled condenser as the sole heat transfer mechanism and couples it with groundwater supply as the drought tolerance tool. This equipment is sized to provide complete heat rejection on the hot summer day. Again, makeup water is treated rather than the wastewater and the equipment sizing is reduced further since the makeup water demand for the site is reduced.

Economic Analysis

A technical and economic comparison of the four alternatives is shown in Table 1. Option 2 is the recommended arrangement. It offers the best performance coupled with the lowest capital cost.

Table 1 – Heat Rejection Technology Comparison

		Option			
		1	2	3	4
Description		**Wet Cooling with Surface Water Supply**	**Wet Cooling with Groundwater Supply**	**Wet/Dry Cooling with Groundwater Supply**	**Dry Cooling with Groundwater Supply**
Performance					
Net BSP II Output	MW	651	654	658	660
BSP II Heat Rate[1]	Btu/ Kw-hr	8970	8915	9062	9026
Differential Capital Cost	$	$84,190,000	Base	$53,520,000	$71,770,000
Differential Chemical Costs	$/yr	$1,131,500	$1,934,500	$82,344	Base
Differential Net Present Worth	$	$82.1M	Base	$50.4M	$65.0M
Annual Avg Water Consumption					
Evaporation Losses					
Tower	gpm	3,878	3,878	320	0
Makeup Pond	gpm	500	0	0	0
Makeup					
Surface Water	Ac-ft/yr	13,817	13,033	7,291	7,065
Water Treatment Systems Auxiliary Power[4]	kW	6,300	120	90	70
Heat Rejection Auxiliary Power[5]	kW	7,550	7,550	7,955	10,255
Total BSP II Auxiliary Power[2,3]	kW	54,250	50,270	50,515	53,105

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Notes
1.) Net Plant Heat Rate at Boiler MCR and Average Ambient Conditions.
2.) Auxiliary Power at Boiler MCR and Average Ambient Conditions.
3.) BSP I auxiliary power savings are not factored into BSP II heat rate values.
4.) Accounts for both BSP I and BSP II auxiliary power consumption.
5.) BSP II auxiliary power only.

Option 2 does consume more chemicals in the makeup water pretreatment system and may in fact potentially require an additional operator, but these operating costs are relatively minor and therefore could not payback the investment required by any of the other high incremental capital cost alternatives.

Very truly yours,

BLACK & VEATCH

Kermit E. Trout, Jr.
Project Manager

KET/JAH/kjh

cc: Rich Chapman