Appendix C: Cost Estimate Report for a Hypothetical Cooling System Conversion

The Agency conducted a detailed analysis of cost estimates for the hypothetical installation of a cooling tower system at Bowline Point Station along the Hudson River in New York State. The Agency compared the results of its analysis to that included in the Draft Environmental Impact Statement (DEIS) of four Hudson River power plants. Power Tech Associates of New Jersey examined the costs of converting Bowline Point's cooling system from once-through to recirculating in Appendix VIII-3 of the DEIS, which was submitted to New York State in December, 1999. Section IV-B of the DEIS contains detailed information on the existing cooling water system and site characteristics. The Power Tech report presents a narrative review of cooling tower technologies, a description of most key engineering assumptions for and site characteristics affecting unit cost estimates, an environmental impact discussion of the cooling towers, capital cost estimates at the aggregate level, and an economic analysis of these costs.

The focus of the Agency's analysis was to develop detailed unit cost estimates for comparison to the Power Tech aggregate capital cost estimates. Although the Appendix VIII-3 cost estimates are at the aggregate level, the DEIS (in addition to historical engineering work on behalf of the four Hudson plants) provides sufficient detail to afford comparison to detailed unit cost estimates developed by EPA. The sources of cost data and reference information for the Agency's unit cost estimates are presented below. The Agency chose to develop the detailed unit cost estimates for the Bowline Plant, in order to examine the overall veracity of the estimates prepared by Power Tech Associates. The Agency could have chosen to examine any of the four Hudson Plants, but selected Bowline because the degree of detail in the DEIS (and supporting documentation) was high and the uncertainty about site characteristics was the lowest amongst the four plants. For instance, the Agency had intended to also examine the Roseton Station, but was unable to determine the distance between the proposed towers and the condensers from the Power Tech report. In turn, the Agency was unable to develop detailed unit costs for the Roseton Station due to this key data omission.[1]

The Agency notes that the Mirant Bowline, LLC (the new owners and operators of Bowline Point Station) currrently are in the process of obtaining approval for expansion of the plant with planned construction of a third, combined-cycle unit on the site. If this construction commences as planned, the configuration of the plant would be significantly altered. The land proposed by Power Tech Associates for construction of the cooling tower system for units 2 and 3 (as analyzed herein) would likely be utilized in part for the new generating unit. Therefore, for this reason and others, this analysis should be considered hypothetical in nature.

[1] The Agency, however, obtained schematics of the Roseton Station retrofit design (1977) late in the development of this report. The design schematic by Central Hudson (1977, Exhibit 2) proposes nearly complete reuse of the existing circulating piping system with minimal additional circulating piping required to connect the tower system. From the detailed schematic, EPA estimates that the lineal feet of new circulating water piping as less than 900 feet (that is, 2300 feet less than the Power Tech design for Bowline Point Station). In addition, the Central Hudson schematic proposes for the existing intake discharge piping to be completely reused, thereby eliminating the need for new makeup and blowdown piping. Therefore, significant piping and civil works cost savings would be afforded for the Roseton Station over the comparably sized and situated Bowline Point Station. A rough estimate based on the detailed costs of Bowline Point developed by EPA would provide a total project capital cost savings of approximately $6 million.

Bowline Point Station is a fossil-fueled plant cooled by a once-through system withdrawing from the Hudson River. The station is located approximately forty miles north of New York City in Haverstraw. The plant is located on a flat expanse of land. The property encompasses a cove (referred to as Bowline Pond) from which cooling water is withdrawn. The station utilizes two steam generators, each sized at 622 megawatts, nameplate capacity. The units were installed in 1972 and 1974. Their utilization had slumped in the mid-1990s, with a rise shown after 1997. The existing once-through cooling system services two condensers at a maximum design flow rate of 1,110,000 gallons per minute (gpm). However, the plant generally operates with reduced pump usage for a design flow rate of 740,120 gpm. Both of these flow rates represent greater than one percent of the mean tidal flow as presented in the DEIS. The Agency notes that in the facility's response to the detailed questionnaire, Bowline Point reported a significantly lower flow rate for its design intake flow than either capacity described here. In fact, the design intake flow reported by Bowline for the detailed questionnaire was very similar to the average annual intake (in gallons per day) for the year 1998. In turn, the Agency intends to update its questionnaire response database to reflect the design flows above. This is an important fact for the consideration of the Agency's methodology for estimating costs of conversions from once-through to recirculating wet cooling systems (which is outlined in Chapter 2 of this document), as the Agency utilizes the design intake flow as the basis for assessing these costs.

The design circulating cooling flow estimated by Power Tech for the cooling towers is 642,000 gpm. Power Tech based their analysis on four-hybrid, wet-dry cooling towers each with 160,500 gpm of design circulating capacity. Power Tech states in Appendix VIII-3, page 10, "based on a conservative approach, the wet/dry mechanical draft tower was chosen as the best way to evaluate economic…concerns associated with retrofitting cooling towers to the Hudson River plants." As discussed in Grogan (2000), "a wet only (wet mechanical cooling tower) cooling water system will have substantially less environmental impact and be less costly to the NY consumers. The trade-off is that the water vapor plume will be visible during more days of the year." The Agency agrees with the Grogan assessment and considers the benefits of a wet/dry cooling system to be debatable for this installation. In 1977, Consolidated Edison conducted a detailed study of the potential effects of a natural-draft wet (only) cooling tower on the local environment near the Roseton Generating Station. The analysis of plume effects from the natural-draft towers (each projected to be about 400 ft tall) showed induced fogging at the station for a total of 85 hours per year, with a peak in February of 40 hours (Con. Ed, 1977; Table 4-1). Outside of 0.8 miles from the station the study predicted 7 hours or less of fogging, in any direction, for the entire year. Plume induced icing, according to the 1977 study, would occur for a total of 45 hours in a single year at the station itself. Outside of 0.8 miles the total hours of icing for any nearby area would be 6 hours or less per year. Because of the similarities in size and location between Roseton and Bowline Stations, the Agency considers these results to be relatively transferable to the Bowline Point location. However, the remote fogging and icing effects of a natural-draft tower system would be significantly greater than those for a comparably sized mechanical-draft tower, which would be roughly 50 feet in height with a plume that is approximately 30 percent smaller than that of a natural-draft tower. In addition, Central Hudson, et al. (1977) quantified the economic impacts of these effects in the *Report on Cost-Benefit Analysis of Operation of Hudson River Steam-Electric Units with Once-through and Closed-cycle Cooling Systems*. In the report the authors state, "the impact of the operation of the proposed closed-cycle cooling systems in terms of induced fog and icing is not expected to be substantial." This summary refers to the combined total of the four power plants potentially converting to natural-draft wet cooling tower systems. The effects for less than four plants (or a single plant) converting to a mechanical-draft wet cooling tower system would be even less pronounced. Therefore, based on these 1977 analyses by Con. Ed. and Central Hudson, et al., the Agency considers the mechanical draft wet (only) cooling towers to be a viable option for Bowline Point.

Regardless of the configuration of the tower (that is, wet only or hybrid, wet-dry), the cooling flow would be equivalent between the two types. Additionally, the land requirements, site preparation, and civil construction would be nearly identical for both types of tower installations, with the exception of potential support piling requirements. For the wet-dry models, marginal additional support piling (due to increased load) may be necessary. The Agency, in its analysis, has estimated all costs based on mechanical-draft wet (only) cooling towers.

Bowline Point is located roughly 30 miles from Poughkeepsie, NY, which is one of the nearest towns to Bowline included in the city cost index of R.S. Means. The R.S. Means City Cost Index contains other towns in the vicinity of Haverstraw in addition to Poughkeepsie, such as Suffern and White Plains. Haverstraw is, in effect, equidistant from each of these three cities. Poughkeepsie's cost index represents the median and near to the average of these three surrounding city cost indexes. Therefore, the Agency utilized costs index multipliers specific to the median of these three cities for its cost estimates. The DEIS states that truck traffic through Haverstraw would be disruptive to the town, which the Agency cannot dispute. Therefore, in all cases, the Agency estimated the hauling requirements as conservative (that is, small to medium trucks) and to account for alternative routing (that is, long round-trips) to minimize and avoid town traffic disruptions. Additionally, the Bowline Point site covers 245 acres. Based on the detailed aerial photographs (proprietary photos published by www.mapquest.com **and available to the general public through the website, but not for publication), significant available land for staging of construction operations is available.**

Power Tech estimates that the cooling tower system would occupy a total of 6 acres. However, they assert that 13 acres would require clearing and preparation for construction. The plot of land projected for construction would be approximately 800 feet east of the generators in a relatively low-lying, flat area. Power Tech assert that this plot of land is populated by second-growth timber. Detailed aerial photographs reveal brush and small trees covering approximately half of the 13 acres. Additionally, the Power Tech report asserts that the land shows signs of being wetlands, but the body of the DEIS states that the NY DEC does not designate any wetland areas on the Bowline Point property. The USDA soil survey included in Appendix IV-B.1-1 indicates that the tower would be constructed in part urban land, part wet substratum. Based on these factors, the Agency's analysis estimates that significant dewatering control and foundation piling would be required for the construction project.

The existing intake structure is a surface shoreline intake located to the south and west of the generator units. The intake pumps sit immediately behind the intake screens, and, due to a lack of proximity, would not be of use for circulating cooling water between the projected cooling tower location and the condensers. The intake and discharge piping passes approximately 150 meters immediately to the east of the generator house and bends southwesterly to and from the discharge and intake. This piping is in relatively close proximity to the projected location of the cooling towers and could be used for a retrofit design, though, notably, Power Tech does not address this prospect in their engineering assessment. In turn, the detailed cost estimates included in this file estimate that only the existing intake and discharge structures will be used for the conversion design and minimal existing piping will be utilized. Based on the example cooling system conversion cases discussed in Chapter 4, the Agency views this design as potentially unrealistic and perhaps overly conservative with respect to capital costs. In addition, as discussed in footnote 1 above, the detailed engineering schematics the Agency obtained for

the historical, proposed Roseton Generating Station cooling system conversion show significant reuse of existing circulating water piping for that design.

Based on the detailed description provided in the DEIS, the existing intake bays present flexibility for converting to a reduced intake flow for makeup cooling water. Because the intake is comprised of 6 separate bays with dedicated pumping stations, several of the bays could be retrofitted with a reduced size pump or a new variable speed motor to provide makeup water to the cooling towers. The piping delivery to the tower could be configured to branch from the existing piping. Other configurations that maintain the capability to return to once-through cooling could be examined (such as diverting the flow from two bays to the makeup piping and retaining the other four bays for peak-demand, once-through operation). For the Agency's conservative analysis, the design assumes demolition and replacement of three intake pumps, in addition to construction of wholly new intake and discharge piping.

The subject of plant outage for conversion of the cooling system is addressed in Appendix VIII-3 of the DEIS (page 19), where Power Tech states, "it was assumed that each of the [Bowline and Roseton] plants would experience about one month of outage during the winter months." EPA notes that several data sources indicate that the outages could be appreciably lower than this estimate. One data source is an engineering report on Roseton Station from Central Hudson Gas & Electric Corporation (July 1977), which estimates, "as a conservative approach…the downtime cost was calculated for one (1) unit and for ten (10) days," to convert from a once-through to recirculating cooling system. Additionally, the Agency obtained two empirical examples of cooling system conversion projects with durations in one-case significantly less than thirty days and 83 hours in the other (as discussed in the Chapter 4).

The results of the Agency's detailed cost analysis for Bowline Point show that the capital cost estimates presented in Appendix VIII-3 of the DEIS overstate the potential cost to convert from a once-through to recirculating cooling system. The Agency did not compare each line item of the Power Tech prepared capital costs in Appendix VIII, but, rather, focused on the civil works estimates. The Agency prepared two sets of cost estimates: high unit costs and moderate unit costs. The Agency based the high unit costs on extremely conservative assumptions for design variables. The moderate costs are also conservative, but utilize optimized design variables that would reflect a moderate engineering cost estimate. In both cases, the Agency's analysis demonstrates that the Power Tech estimates overstate direct capital costs by approximately 24 to 36 percent. Further, the Agency disagrees with several estimates of project overhead rates used by Power Tech.[2] Considering the total project costs differences, in the Agency's view, the Appendix VIII-3 estimates may overstate total project capital costs by 31 to 42 percent. As described above, the Agency disputes the utility of the wet-dry, hybrid tower for this location. The Agency considers the incorporation of this technology into the DEIS analysis, as stated in Appendix VIII, to be an overly conservative approach. The Agency's analysis, therefore, focuses on the wet only mechanical draft tower system. However, had the Agency incorporated the Power Tech cost estimates for the wet-dry, hybrid system, the Appendix VIII-3 total project capital costs would remain overestimated by 20 to 30 percent, according to the Agency's analysis. Table C-1 shows the Agency's unit cost estimates as compared to those included in Appendix VIII-3 of the DEIS.

[2] In the Agency's view, Appendix VIII-3 incorrectly states the tax rate for New York State, double-counts contractor profit, and double-counts freight and insurance on materials.

Table C-1. Capital Cost Comparison for Hypothetical Cooling System Conversion			
Cost Component (1999 $)	**App. VIII-3 Estimated Capital Costs**	**EPA Estimated Capital Costs - Moderate**	**EPA Estimated Capital Costs - High**
Cooling Towers	**21,009,935**	**11,063,569**	**11,063,569**
Site Preparation Excavation/Backfill for Towers Piling for Towers CW Piping Civil Works CW Pipe CW Pumphouse Civil/Structural CW Pumps CW Pumphouse Cranes	**41,099,318**	**26,326,577**	**35,084,076**
Concrete Basin for Towers	**2,450,963**	**2,450,963**	**2,450,963**
~~Condenser Tube Cleaning~~	**2,081,000**	**-**	**-**
Water Treat and Chem Add Electrical Instrumentation & Controls	**8,677,100**	**8,677,100**	**8,677,100**
Total Direct Cost (TDC)	**$ 75,318,316**	**$ 48,518,208**	**$ 57,275,708**
~~Freight & Ins~~	**2,644,788**	**-**	**-**
Eng & Design	**4,519,099**	**2,911,092**	**3,436,542**
Indirect & Und Costs	**7,531,832**	**4,851,821**	**5,727,571**
Construction Mgt	**3,012,733**	**1,940,728**	**2,291,028**
Sales Tax	**696,301**	**191,264**	**191,264**
Contingency ~~& Contractor Profit~~	**15,063,663**	**4,851,821**	**5,727,571**
Turnkey Contract Cost (TCC)	**$ 108,786,731**	**$ 63,264,934**	**$ 74,649,684**
Owner's Costs (3% of TCC)	**3,263,602**	**1,897,948**	**2,239,491**
Start-up & Testing (0.5% of TCC)	**543,934**	**316,325**	**373,248**
Total Project Cost	**$ 112,594,000**	**$ 65,479,000**	**$ 77,262,000**
Approximate $ per kW (nameplate)	91	53	62

Note that the Agency utilized the capital costs for concrete basins, water treatment and chemical addition, and instrumentation and controls presented in Appendix VIII-3 of the DEIS without examining the basis of the cost estimates. In addition, the Agency did not utilize the condenser tube cleaning system as proposed. In the Agency's view, this is a cost that would benefit the performance of the condensers regardless of the cooling system in operation and would not be a critical component of cooling system conversion. The detailed unit cost worksheets developed by the Agency are in the public record of this proposal at DCN 4-2537. The Agency utilized the following references in preparation of the analysis:

References Used in the Cost Analysis:

J.M. Burns and Michilletti, W.C., 2000, "Comparison of Wet and Dry Cooling Systems for Combined Cycle Power Plants," Appendix F to the Comments of the Utility Water Act Group (UWAG) on EPA's Proposed Sec. 316(b) Rule for New Facilities.

J.M. Burns and Tsou, J.L., 2001, "Modular Steam Condenser Replacement Using Corrosion Resistant High Performance Stainless Steel Tubing," Proceedings of the 2001 Conference of the American Society of Mechanical Engineers.

Central Hudson Gas & Electric Corporation, 1977, "Engineering, Environmental (Non-Biological), and Economic Aspects of a Closed-Cycle Cooling System," Roseton Generating Station.

Central Hudson Gas & Electric Corporation, et al., July 1977, "Report on Cost-Benefit Analysis of Operation of Hudson River Steam-Electric Units with Once-through and Closed-cycle Cooling Systems," prepared by Mathtech, Inc., a subsidiary of Mathematica, Inc.

Central Hudson Gas & Electric Corp., et al., 1994, "Utility Responses to New York State Department of Environmental Conservation/Tellus Institute Commnets and Questions on Preliminary DEIS for SPDES Permits for Indian Point 2 and 3, Bowline, and Roseton Power Plants."

Central Hudson Gas & Electric Corp., et al., December 1999, "Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3, and Roseton Steam Electric Generating Stations."

Consolidated Edison Company of New York, Inc., 1977, "Environmental Analysis of Natural Draft Cooling Towers for Roseton Generating Station," prepared for Central Hudson Gas & Electric Corp.

Construction Industry Institute, 2001, "Benchmarking & Metrics Analysis Results - What is the Average Contingency for Heavy Industrial Projects?" http://www.cii-benchmarking.org/news/contingency.htm**, Austin, Texas.**

Engineering News-Record, 2002, "Construction Cost Index History (1908-2002)," http://www.enr.com/cost/costcci.asp**, McGraw-Hill, Inc., New York.**

D.B. Grogan Associates, Inc., 2000, "Hudson River Power Plants - Cooling Water Design Assessment," prepared on behalf of ESSA Technologies, Ltd. for support of the New York State Department of Environmental Conservation.

S.H. Kosmatka and Panarese, W.C., 1992, "Design and Control of Conrete Mixtures, Thirteenth Edition" Portland Cement Association, Skokie, Illinois.

W.L. McCabe, et al., 1985, "Unit Operations of Chemical Engineering, Fourth Edition," McGraw-Hill, Inc., New York.

Page, J. R., Senior Editor, 1998, "RS Means Heavy Construction Cost Data, 12th Edition," R.S. Means Company, Inc.

Parsons Infrastructure and Technology, 1998, "Market-Based Advanced Coal Power Systems," Parsons report no. 10198, Reading, Pennsylvania.

M.S. Peters and Timmerhaus, K.D., 1991, "Plant Design and Economics for Chemical Engineers, Fourth Edition," McGraw-Hill, Inc., New York.

U.S. Army Corps of Engineers, 1998, "Conduits, Culverts, and Pipes," engineer manual 1110-2-2902.

USGen New England, 2001, "Section 316b Demonstration Report," submitted to the New England Interstate Water Pollution Control Commission.

Waier, P. R., Senior Editor, 2000, "RS Means Building Construction Cost Data, 58th Edition," R.S. Means Company, Inc.

THIS PAGE INTENTIONALLY LEFT BLANK