

**Attachment 1****ECONOMIC AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH  
CONVERSION OF INDIAN POINT UNITS 2 AND 3 TO A CLOSED-LOOP  
CONDENSER COOLING WATER CONFIGURATION****(2003 Report)****2003 Report****2003 Report, Attachment 1****2003 Report, Attachment 2****2003 Report, Attachment 3****2003 Report, Attachment 4****2003 Report, Attachment 5****2003 Report, Attachment 6****2003 Report, Attachment 7**

ECONOMIC AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH  
CONVERSION OF INDIAN POINT UNITS 2 AND 3 TO A  
CLOSED-LOOP CONDENSER COOLING WATER CONFIGURATION

Prepared for  
Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC

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### Summary of Report Conclusions

At the request of Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC (collectively, "ENIP2/3"), Enercon Services performed an evaluation of the feasibility of converting Indian Point Unit 2 and Indian Point Unit 3 to a closed-loop condenser cooling water configuration, and an assessment of the associated economic and environmental impacts. Since comparable conversions do not exist for direct comparison, due to the complexity and extensive nature of the task, appreciable efforts were devoted to development of a feasible conceptual design, evolved to the level of detail necessary to support subsequent assessments of economic and environmental impact.

Although no method of waste heat dissipation could support Unit 2 and Unit 3 (collectively, the "Station") performance as well as the existing once-through cooling scheme, due to the turbine and condenser design which rely on the low-temperature River water, cooling towers offered the only feasible alternative. Due to Station-specific environmental characteristics, a tower with visible plume abatement and noise abatement was deemed necessary. Additionally, due to the heavily timbered site, with rocky terrain and rapid elevation changes, a tower with a minimum footprint was required to reduce overall excavation and clearing. A single round hybrid cooling tower for each unit was found to best meet the Station performance needs and minimize environmental impacts.

The selected tower type provides the minimum environmental impact of any currently available. The site aesthetics, particularly from River-side view points, are somewhat compromised by the addition of the towers, but much less so than by other alternatives. The effluent from the tower increases salt deposition in the area of the Station, but less so than other types of towers with higher effluent drift rates, and at a level comparable to existing Station background levels. Construction activities during the implementation phase will have a negative local impact with the associated increased traffic and noise, but would have restrictions to minimize the severity of their impact during construction.

Due to some extent to Station-specific conditions, the conversion to closed-loop cooling would be extremely complex and expensive, in terms of initial direct capital costs, lost generating capacity during construction outages, and the de-rating of Station generating capacity. Particular efforts were made to accurately assess direct capital costs of the proposed conversion. Assumptions were minimized by developing the conceptual design to the point that preliminary major equipment selections could be specified, and budgetary quotes obtained from vendors. The extensively revised electrical distribution system was modeled with computer software, and preliminary drawings developed. Attachments 1 and 2 of this Report include the various vendor submittals and conceptual drawings utilized to develop accurate capital cost estimates detailed in Attachment 6. The estimated direct capital cost of the conversion is \$612,400,000.00, without any level of contingency. With customary cost of a performance bond and a 20% contingency, the engineering, procurement, and construction costs approach \$740,000,000.00.

Since the changes to the condenser cooling systems involve the very heart of the plant, much of the conversion must be completed with both Units in a forced outage. Although much of the excavation work and cooling tower erection can be done pre-outage, new circulating water pumping stations and changes to the Station's common discharge canal force a major outage. Based on the detailed construction schedule included in Attachment 6, with as much work designated pre-outage or post-outage as possible, the forced outage duration is about 42 weeks. Again, this is an estimate without any level of contingency, and is likely greatly conservative. If

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the duration of a normal refueling outage, 28 days or less, is deducted from this, the duration of lost generating capacity for ENIP 2/3 is 38 weeks. At average Station generation capacities and projected short-term New York wholesale costs of electricity, this amounts to a loss of approximately 13 million megawatt-hours, at a cost of nearly \$630 million dollars.

Utilizing mechanical draft cooling towers instead of once-through cooling introduces significant additional electrical loads, termed “parasitic losses”, that reduce Station output. For the particular hybrid towers selected, the average annual parasitic losses can be estimated to a high degree of accuracy. The towers have “wet” and “dry” section fans, 44 in each section, at 300 and 350 horsepower, respectively. Additionally, for the closed-loop configuration, circulating water pump horsepower is also increased. The net effect is an annual average parasitic loss of approximately 26 megawatts each Unit.

Moreover, converting the condenser cooling system of an existing plant presents fundamental design problems. The heart of the design of the condenser and turbine is based of the anticipated temperature of the condenser cooling water. If the condenser cooling water is not as cold as the as-built design requires for optimal performance, then the condenser heat rejection is reduced and the backpressure on the turbine increased. With an increase of backpressure on the turbine, performance is significantly affected, and ultimately generator output is reduced. This issue is of significant consequence at the Station. River water temperatures are low throughout the year, and the condenser/turbine package was designed accordingly. Cooling towers, through evaporative cooling, cannot match the low temperature of the River intake. In the winter months the impact is lessened, but during the summer Station performance will suffer appreciably. Lost generation, at maximum load conditions, would be approximately 47 megawatts for Unit 2, and approximately 27 megawatts for Unit 3. On an annual average basis, the effect is less, but still significant at about 15 megawatts for Unit 2 and about 6 megawatts for Unit 3.

Finally, the conversion will result in increased Operation and Maintenance (O&M) costs. With the large number of high horsepower fans, associated electrical distribution system, and increased horsepower circulating water pumps, increased O&M costs are incurred. These costs increase with the number of years the equipment is in service, but can be approximated based on input from the respective vendors. Water treatment costs also increase due to the closed-loop conversion, and will add to the O&M costs. The increased annual cost for each Unit is conservatively estimated at \$1.5 million/year, for years 1-5, \$2.0 million/year, years 6-15, and \$3.0 million/year, years 16-30, assuming an approximate thirty year remaining life for each Unit.

In final summary, the economic impact of the proposed conversion, due primarily to the scope and complexity of the change, but further increased by Station-specific issues, is enormous. The direct capital costs of the conversion approach \$740 million dollars, and the associated lost generating capacity during implementation is estimated to cost approximately an additional \$600 million. Annual operating expenses increase, and generating capacity is significantly decreased. There are some minor negative environmental impacts associated with the conversion; however, other than site aesthetic issues, these are interim issues associated with construction.

## 1.0 Background and Introduction

Indian Point 2 and Indian Point 3 were placed into service in the mid-1970's. Both Units are pressurized water reactors (PWRs), with respective net capacities of 940 MW and 970 MW. Located on the east side of the Hudson River in the town of Buchanan, each Unit utilizes a once-through type condenser cooling water system; (i.e., circulating water system) with the intakes from and a shared discharge canal to the Hudson River. The normal design flow rate of the circulating water system for each unit is 840,000 gpm.

The existing once-through circulating water scheme provides both the lowest cost method of condenser cooling and supports the highest level of Station capacity, with corresponding environmental benefits not within the scope of this Report. However, Enercon Services, Inc. (Enercon) was retained to evaluate possible configurations that may substantially reduce River intake, and the associated costs and environmental impacts. In particular, Enercon considered conversion of the existing system to a closed-loop circulating water system configuration. Although various methods of heat rejection generally exist for closed cooling water systems, the only feasible choice for Indian Point 2 and Indian Point 3 requires the use of cooling towers. This conclusion is confirmed by several other studies/reports performed in the past [References 5.1, 5.2, and 5.3]. Heat (thermal energy) is a by-product of the generation of electricity. The primary heat dissipation system, an integral part of power generation, is designed to dissipate, or transfer, this energy to the environment. In a closed-loop system utilizing a cooling tower, water from the circulating water system is pumped through the condenser and then to the cooling tower where heat, transferred to the cooling water in the condenser, is dissipated to the environment (the atmosphere) by evaporation. While different types of cooling towers exist, with varying levels of cost, performance, and environmental performance, existing site conditions effectively limited the cooling tower configurations that reasonably could be considered for Indian Point 2 and Indian Point 3.

Two critical introductory observations also warrant mention. First, Enercon is aware of no conversion of an existing operating nuclear-powered electric-generating station of the size or configuration of either Indian Point 2 or Indian Point 3 from open-cycle to closed-cycle cooling. Thus, assumptions about feasibility, while based on best professional judgment, do not have the benefit of either available technology or past efforts. Second, estimated costs are based, likewise, upon best professional judgment. Thus, given the absence of any practical applications, costs are likely to be understated. As such, the costs discussed in this Report are highly conservative.

This Report provides the following:

- A feasible conceptual design, refined to the level of detail necessary to support cost estimates and a qualitative assessment of environmental impacts resulting from the conversion. The assessment of economic impacts includes initial capital costs, installation costs, operation and maintenance (O&M) expenses, and Station capacity impacts associated with the selected configuration.
- A preliminary qualitative assessment of certain environmental impacts associated with the proposed changes is also included. Certain negative and positive impacts are identified, and preliminarily quantified. These include such issues as cooling tower plume and noise generation, site aesthetics, construction related impacts, and River intake flow.

## 2.0 Conceptual Design

As discussed above, we are aware of no conversion of existing operating nuclear stations from once-through to closed-cycle cooling. Even without this significant uncertainty, conversion of an existing, operating power plant from once-through condenser cooling to closed-loop condenser cooling represents a massive engineering and construction undertaking in the best of circumstances, even when site conditions are conducive to the required configuration changes. In contrast, the Indian Point site, with appreciable elevation changes, a general lack of available space, a subsurface primarily composed of solid rock, the location of a major interstate gas pipeline and the relevant aesthetic considerations (among other factors), poses significant additional site-specific challenges. While the total impact of all of these factors cannot be fully established, certain critical measures play a significant role in determining the feasibility and the appropriate configuration of any proposed closed-cycle system, as discussed in the following sections.

### 2.1 Major Components

Evaporative cooling towers are the selected mechanism for rejecting waste heat in this Report. As evaluated in previous reports [References 5.1, 5.2, and 5.3] and during the initial stages of this effort, other alternatives for heat rejection, such as evaporative ponds, spray ponds, or cooling canals, all require significantly more real estate to implement than exists at the Indian Point site. Similarly, dry cooling towers, which rely totally on sensible heat transfer, lack the efficiency of wet or hybrid towers using evaporative cooling, and thus require a far greater surface area than is available at the Indian Point. Additionally, due to their lower efficiency, dry towers are not capable of supporting condenser temperatures necessary to be compatible with either Unit's turbine design and, therefore, are not a feasible technology.

#### Cooling Towers

Theoretically possible cooling tower configurations are discussed below:

##### Natural Draft Towers

Of the available types of evaporative cooling towers, the natural draft "wet tower" is comparatively efficient, quiet, moderate in initial cost, moderate in footprint (i.e., 450 feet in diameter), and under appropriate circumstances, can be less costly to operate. Thus, given suitable site conditions, the natural draft tower can be a sound choice. However, natural draft towers rely on the "chimney effect" of the tower to create the required draft; hence, the tower must be very tall, approximately 450 to 550 feet in height. Therefore twin structures, one for each operating Station, approximately 450 feet in diameter and in excess of 500 feet high would be required. Figure 2.1 illustrates a typical natural draft cooling tower.

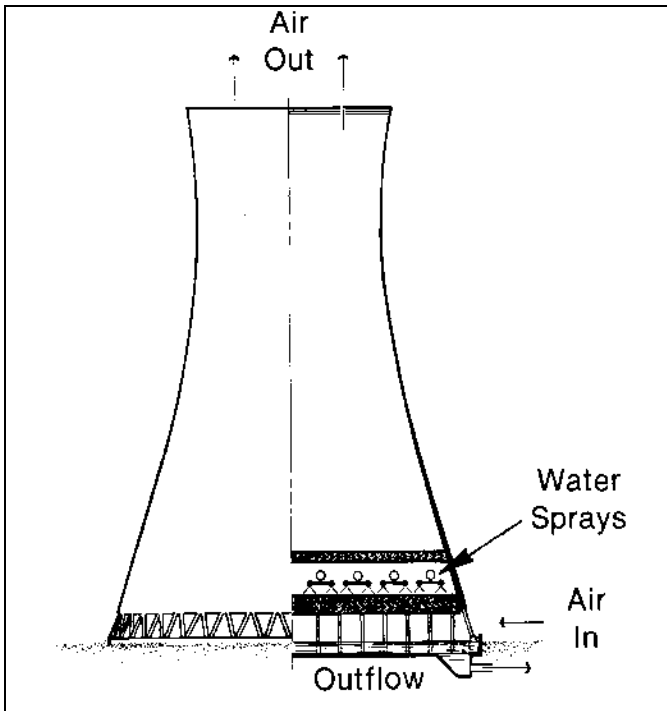


Figure 2.1 – Counterflow Hyperbolic Natural Draft Cooling Tower [Reference 5.4]

Air flow through the tower is produced by the density differential that exists between the heated (less dense) air inside the stack and the relatively cool (more dense) ambient air outside the tower. Since these towers depend on their geometric shape rather than fans for required air flow, they have low operating costs.

Hyperbolic towers are quite large. In the capacity required for Indian Point, a single tower per unit would be in excess of 500 feet in height.

### Mechanical Draft Towers

A mechanical draft wet cooling tower can be comparatively efficient, typically lowest in initial cost, moderate in footprint, and with moderate operating costs. However, due to the need for forced draft fans, this type of tower has slightly higher noise levels than a natural draft tower. This technology is considered impractical for the Indian Point site, because of risks created by its associated plume. In particular, under dominant atmospheric conditions at the site, a dense visible cloud of water vapor and entrained water droplets would be emitted from the tower that could have the following negative aspects:

- Compromises Station operations, safety, and systems, particularly over time
- Interferes with plant visual-oriented security systems
- Dominates the skyline in the area of the plant
- Creates local fogging and icing conditions in winter
- Long-term shadow from plume can harm vegetation
- Associated salt deposition could harm plants in the area
- Can be ingested into tower intakes (recirculation), degrading performance.

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Figure 2.2 illustrates the air flow path through a cell of a typical mechanical draft wet cooling tower, and the applicable simplified psychrometric chart.

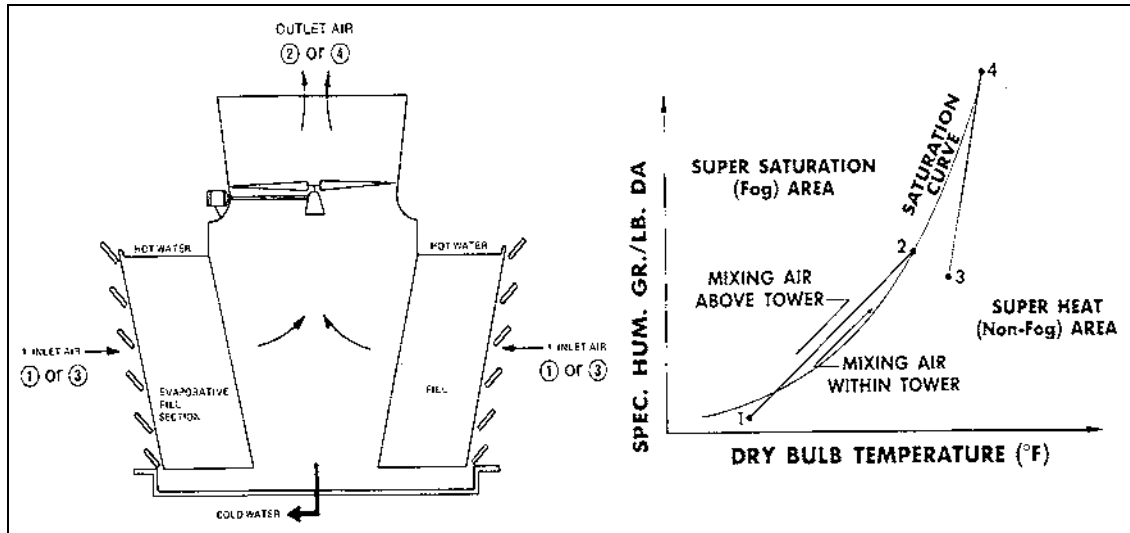


Figure 2.2 – Saturation of Air In Typical Mechanical Draft Wet Cooling Tower [Reference 5.4]

Two cases are depicted in the above figure. Case 1, during summertime, ambient air enters the tower at condition 3 and exits saturated at condition 4. After leaving the tower, this saturated air mixes with the ambient air along line 4-3, most of which mixing occurs in the invisible region below the saturation curve of the psychrometric chart. Case 2, winter ambient air enters the tower at condition 1, exiting saturated at condition 2 and returning to ambient conditions along line 2-1. As can be seen, most of this mixing occurs in the region of super-saturation, which causes the visible plume to be very dense and very persistent.

### Hybrid Towers

A hybrid, also referred to as a “wet/dry” or “plume abated” cooling tower, addresses many of the shortcomings of the tower types previously evaluated, particularly as applies to the Indian Point site. Basically, a hybrid tower is the combination of the wet tower, with its inherent cooling efficiency, and a dry heat exchanger section used to eliminate visible plumes in the majority of atmospheric conditions. After the plume leaves the lower “wet” section of the tower, it travels upward through a “dry” section where heated, relatively dry air is mixed with the plume in the proportions required to achieve a non-visible plume. Hybrid towers are slightly taller than comparable wet towers, typically ~70 feet elevation at the discharge versus 60 feet, due to the addition of the “dry” section, and may require a larger footprint. They are also appreciably more expensive, both in initial costs and in ongoing operating and maintenance costs. A potential exists for increased noise due to additional fans in the dry section, although attenuation to acceptable levels is possible, again at a cost.

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Hybrid towers are available in different configurations. Figure 2.3 illustrates the air flow path through a cell of a parallel path hybrid tower, and the applicable simplified psychrometric chart.

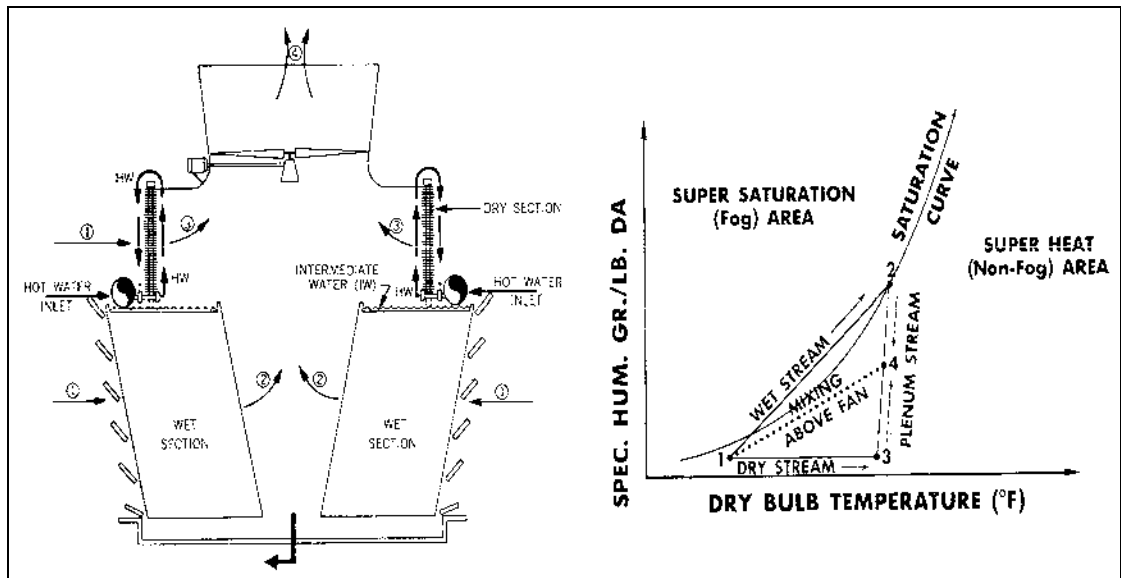


Figure 2.3- Partial Desaturation of Air In A Parallel Path Hybrid Tower [Reference 5.4]

A hybrid cooling tower is designed to drastically reduce both the density and the persistency of the plume. Incoming hot water flows first through the dry heat exchanger (finned coil) sections, then through the wet (evaporative cooling) fill section. Parallel streams of air flow across the coil sections and through the fill sections, leaving the coil sections at dry condition 3, and leaving the fill sections at saturated condition 2. These two separate streams of air then mix together going through the fans, along the lines 3-4 and 2-4 respectively, exiting the fan cylinder at sub-saturated condition 4. This exit air then returns to ambient conditions along line 4-1, avoiding the region of super-saturation (visible plume) altogether in most cases.

The round hybrid tower has attributes and features suited for power plants in general (see Figure 2.4):

- The concentrated center plume provides inherent advantages over the individual cell plumes generated by linear hybrid towers. The round hybrid tower plume is not susceptible to recirculation to the tower inlets, increasing tower performance [Reference 5.5]. Additionally, the center plume is discharged at a higher elevation, approximately 165 feet, and reaches significantly greater heights due to the flow velocity and thermal concentration created by the central discharge shroud. This feature promotes distribution of entrained salts over a much larger area, thus lowering concentrations, and largely eliminates ground level plumes that could compromise Station systems, including plant security.
- The round tower has an appreciably smaller size footprint than an equal capacity linear tower. With the high excavation costs at the Indian Point site, the smaller required footprint represents significant cost savings. The round design, at approximately 500 feet in diameter for the required capacity for each Unit, compares favorably to a linear tower that could approach 1500 feet in length, running parallel to the River shore.

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- Less piping, in a simpler configuration, is required for a round tower. Only a single, or pair depending on capacity, of supply and return lines is required for a hybrid tower. For a linear tower, individual supply pipes must feed each cell. For either Indian Point 2 or 3, depending on cell size, a pair of 18- to 24-cell towers would be required per Station.
- Separate forced draft fans in front of the wet and dry sections provides operating flexibility and appreciable operational cost savings. The number of the wet section fans in operation can be adjusted to ensure optimum cooling water temperature, and speed adjustment of the dry section fans controls the required hot air flow rate for plume-free operation. Fully automated, energy saving process control is thus achieved by these towers [Reference 5.6].

Attachment 1 to this Report contains additional information relative to round, hybrid cooling towers. A caveat is warranted. The round hybrid tower represents the latest in technology. Only a single comparably sized tower currently has been constructed at a *new* (not existing) facility, and that facility is not located in the United States. As such, there is no directly applicable information regarding costs attributable to retrofitting a power plant using such a tower.

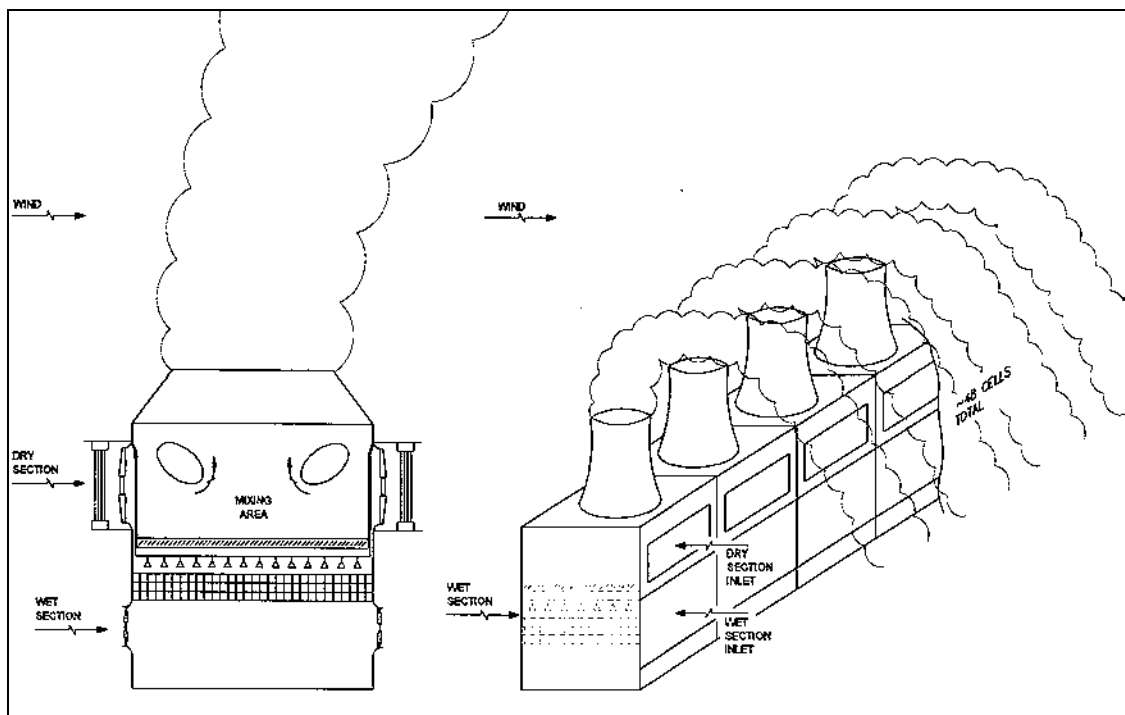


Figure 2.4 – Inherent design advantages of round hybrid tower versus linear cell-type hybrid tower.

The above figure illustrates some of the advantages of a round hybrid tower versus a linear cell-type hybrid tower. The concentrated center plume provides inherent advantages over the individual cell plumes generated by cell type linear hybrid towers. The round tower plume is not susceptible to cross-wind induced recirculation to the tower inlets, increasing tower performance. Additionally, the center plume reaches greater heights, distributing any salt deposition over a much larger area, hence lowering concentrations, as well as decreasing ground-level icing and fogging.

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*Dedicated fans for the dry and wet sections of the round hybrid allows efficient tower usage, with the dry section fans operating at reduced capacity when ambient conditions don't dictate their usage for plume control. Linear, cell-type hybrid towers have a single fan per cell, inducing flow through both sections, hence operate at full fan power at all times.*

#### Circulating Water Pumps

Aside from the cooling towers, the most significant components in converting to a closed-loop condenser cooling configuration are the new circulating water pumps. Whereas the existing once-through configuration required only enough pumping head (pressure) to overcome flow losses in passing water from the River through the condenser and returning to the River, any of the above configurations requires increased pump head to pump the circulating water up to the elevated cooling tower spray headers, and overcome the significant internal flow losses of the cooling tower. Whereas the existing Unit 2 and Unit 3 circulating water pumps were designed for 21 feet and 29 feet of head respectively, the new pumps are expected to be required to produce approximately 72 feet of head. (The number of pumps is expected to stay consistent with the existing configuration; i.e., six pumps per unit. The flow capacity will be slightly decreased, from the existing pump's 140,000 gpm maximum, to approximately 117,000 gpm.) The existing pumps were designed to operate at significantly reduced flow at low River water temperatures, reducing River intake flow. Since the condenser inlet water temperature will remain largely constant with the closed-loop arrangement, single speed/flow rate pumps are adequate and appropriate for the new configuration. Attachment 1 contains reference information on the proposed new pumps.

The cooling towers and the circulating water pumps represent significant additional electrical loads. Preliminary data for the hybrid tower indicates that, at maximum conditions, (44) 300 HP fans and (44) 350 HP fans will be in-service for each tower. A new substation, fed directly from the switchyard, will be required to supply electrical power to each tower. Likewise, the existing circulating water pumps for have, respectively, 1000 HP and 1250 HP motors (at high speed). The new pumps will require an estimated 3000 HP each (single speed). A dedicated substation, fed directly from the switchyard, will be required for each new pumphouse. Attachment 1 contains reference information on the new transformers and associated electrical switchgear for both the tower substations and the pumphouse substations.

#### 2.2 Site Layout for Conversion

Refer to Attachment 2, Sketch 01, for a simplified site layout of the proposed configuration.

The new cooling towers are relatively large due to the required capacity, the outside diameter of each tower, including noise attenuators, is approximately 560 feet. To provide construction access for tower erection and clearance for air intake, the excavation diameter for each tower will be approximately 700 feet. Height of the proposed towers is approximately 150 feet. The location for the Indian Point 2 tower is expected to be approximately 1050 feet north of the Indian Point 2 reactor, just north of the proposed interim spent fuel storage slab installation (ISFSSI) location. The location of the Indian Point 3 tower is expected to be approximately 1000 feet south of the Indian Point 3 reactor. The basin elevation of each tower is dictated by the required head for flow

through the condenser, and preliminary analysis indicates an elevation of 31 feet mean sea level is required.

The location of the circulating water pumphouse is expected to change from the inlet side of the condenser (intake pumping station) to the outlet side on a modified portion of the existing discharge canal; this is to avoid overpressurizing the condenser with the new higher pressure circulating water pumps. The new enclosed pumphouses, Attachment 2, Sketch 02, would supply circulating water to the new towers via (2) 120 inch diameter, AWWA specification, concrete-lined steel pipes. As discussed above, the necessary head for circulating water flow through the condenser would be provided by the static head achieved from the elevation of the cooling tower basin. Flow from the basin to the condenser is expected to be via (2) 144 inch diameter, AWWA specification, concrete-lined steel pipes (Attachment 1).

Associated electrical power supply modifications are also shown on Sketch 01. Due to the general lack of reserve power supplies in the electrical distribution system at Indian Point, and to the appreciable power requirements of the new cooling towers and pumphouses, a dedicated substation supplied directly from the 138 kV off-site switchyard will be required at each tower and each pumphouse.

For each tower, a pre-fabricated metal building, Attachment 2, Sketch 03, would be required to house the substation transformers (Indian Point 2 only), switchgear, and tower control system. The substation for each tower must be located as close as practical to the tower, to reduce cable runs from the substation to the tower. All fans are expected to be provided with 4.16 kV windings. For the Indian Point 2 tower, the substation is expected to be supplied from the switchyard via overhead 138 kV transmission lines. On the Indian Point 3 side, the tower is expected to be supplied via combination of overhead 138 kV transmission line to a new 138 kV/6.9 kV transformer, and underground 6.9 kV duct banks to the switchgear building.

Each pumphouse must have a dedicated 138 kV transformer feeding the switchgear. For the Indian Point 2 pumphouse, the transformer is expected to be located in the Unit 1 switchyard, and 6.9 kV power is expected to be fed to the pumphouse switchgear via above ground cable trays. For the Indian Point 3 pumphouse, the transformer is expected to be located in the Indian Point 3 switchyard, and 6.9 kV power will be fed to the pumphouse switchgear via a combination of ductbank and above ground cable trays.

### 2.3 Operational Features and Schemes

Hybrid cooling tower operation – To efficiently utilize a hybrid tower, an automated control system is required [Reference 5.6]. Whereas for the Indian Point application the wet section would likely operate at maximum capacity most of the time to maintain condenser inlet water temperatures as near as possible to current design operating parameters, the need to operate the dry section fans at a given capacity will be totally dependent on ambient conditions. A programmable logic control (PLC) system will be utilized to reduce tower operating cost (parasitic losses) to a minimum, while maintaining “plume free” (little or no visible plume) operation at or above the design plume point.

For a given ambient condition, necessary algorithms determine the optimum fan speed for the dry section to achieve the required flow between zero flow and that corresponding to full fan speed. The fans are equipped with infinitely variable speed, frequency controlled motors. Since the (44) dry section fans are 350 HP each, and are needed at full capacity only at maximum ambient design conditions, securing them or significantly

reducing their flow results in appreciable reduction in parasitic losses. Ambient conditions of wet bulb temperature, dry bulb temperature, and wet section airflow input to the PLC. Based on the operating algorithms, the controller adjusts the flow of hot air from the dry section (via fan speed) that mixes with the plume from the wet section such that the resulting combined effluent plume is sub-saturated/superheated, and hence not visible.

An additional parameter for reducing operating costs of the tower will be restricting the plume abatement mode of operation to daylight hours only. Since plume abatement only eliminates visible plume, and plume visibility is not an issue at night due to darkness, there is no benefit in operating at night in the more costly plume abatement mode.

In extremely cold ambient conditions, when full operation of the wet section would result in exiting cold water (condenser inlet water) temperatures less than approximately 60°F, an alternate method of load control would be utilized. Since the wet section fans will operate at full capacity the majority of the time, specifying frequency controlled motors is an unwarranted expense. Therefore, for load control in the wet section, the algorithms input to the PLC will selectively secure wet section fans as required to reduce load capacity. For example, of the total of 48 wet section fans, 40 would be operating and 8 would be idle, the proportion of operating to idle fans determined by the exiting cold water temperature.

Make-up and blowdown, cycles of concentration – The water quality of the Hudson River varies over a great range, primarily relative to the River flow rate. Attachment 4 includes USGS and Indian Point Hudson River water analysis and flow rates, on a monthly basis, over a several year duration. During periods with a relatively high River flow rate, ~40,000 cu.ft./sec., the plant intake is largely fresh water with correspondingly low readings of conductivity, chlorides, and hardness:

Conductivity	= 144 microsiemens/cm
Chlorides	= 90 mg/l
Hardness	= 100 mg/l

When River flows are low, ~4,000 cu.ft./sec., the plant intake is very brackish with correspondingly high readings of conductivity, chlorides, and hardness:

Conductivity	= 13,520 microsiemens/cm
Chlorides	= 6,250 mg/l
Hardness	= 1560 mg/l

When in a closed-loop cooling configuration with cooling towers providing the heat rejection, the evaporation from the towers tends to concentrate the intake water contaminant levels and total dissolved solids (TDS). A “blowdown” flow is required to maintain a design level of “cycles of concentration” by constantly bleeding off some cooling water back to the River. The “make-up” flow must be adequate to replenish water lost to evaporation and drift (entrained water particles carried out in the tower plume), plus the blowdown flow. The cycles of concentration are predetermined based on intake water quality, and suitability of materials in the cooling tower and the condenser.

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Blowdown is calculated as follows [Reference 5.4, and Attachment 1, Marley/Balcke-Durr Data]:

$$B = \frac{E - [(C-1) \times D]}{(C-1)}, \quad \text{where } B = \text{blowdown, } E = \text{evaporation, } D = \text{drift,} \\ \text{and } C = \text{cycles of concentration}$$

Drift can be approximated as  $\text{Water Flow}_{\text{Total}} \times 0.00001 \text{ gpm}$ .

Evaporation<sub>Wet Summer</sub> can be approximated as  $\text{Water Flow}_{\text{Total}} \times 0.0167 \text{ gpm}$  [Attachment 1, Marley Performance Data].

Evaporation<sub>Hybrid Winter</sub> can be approximated as  $\text{Water Flow}_{\text{Total}} \times 0.0081 \text{ gpm}$  [Attachment 1, Marley Performance Data].

For the Indian Point Station, since the intake water quality varies dramatically based on Hudson River flow rate, an acceptable cycles of concentration is dependent on the current intake water quality. For the purpose of this Report, at worst case intake water quality, blowdown and makeup will be based on 3 cycles of concentration. Required makeup flow from the River would thus be:

$$\text{Makeup} = B + E + D \text{ [Reference 5.4], where } B = \frac{E - [(C-1) \times D]}{(C-1)}, \text{ and } C = 3,$$

$$\text{Water Flow}_{\text{Total}} = 700,000 \text{ gpm / unit}$$

$$E_{\text{Wet Summer}} = 0.0167 \times 700,000 \text{ gpm} = 11,690 \text{ gpm}$$

$$E_{\text{Hybrid Winter}} = 0.0081 \times 700,000 \text{ gpm} = 5,670 \text{ gpm}$$

$$D = \text{Water Flow}_{\text{Total}} \times 0.00001 \text{ gpm} = 7 \text{ gpm}$$

$$B_{\text{Wet Summer}} = 5,838 \text{ gpm}$$

$$B_{\text{Hybrid Winter}} = 2,828 \text{ gpm}$$

$$M_{\text{Wet Summer}} = 17,535 \text{ gpm / unit}$$

$$M_{\text{Hybrid Winter}} = 8,505 \text{ gpm / unit}$$

Total plant makeup from the River, summer wet mode tower operation would hence equal $M_{\text{Wet Summer}} = 35,070 \text{ gpm}$
-----------------------------------------------------------------------------------------------------------------------------------

Total plant makeup from the River, winter hybrid mode tower operation would hence equal $M_{\text{Hybrid Winter}} = 17,010 \text{ gpm}$
-----------------------------------------------------------------------------------------------------------------------------------------

Since the water quality of the intake varies so greatly, total intake flow can be further reduced by utilizing an automated control system for makeup flow that adjusts flow rates based on intake water quality. Such systems are available from a variety of providers, and typically monitor chlorides or conductivity as an indicator of overall water quality. The above makeup quantities correlate to worst-case intake water quality conditions. With better intake water quality, the cycles of concentration can be gradually increased by the control system from 3 to 5, yet still provide appreciably better circulating water quality than when using 3 cycles of concentration and worst-case water quality.

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To quantify the impact on the River intake, utilizing the same formula as above, with C = 5:

$$\text{Makeup} = B + E + D, \text{ where } B = \frac{E - [(C-1) \times D]}{(C-1)}, \text{ and } C = 5,$$

$$\text{Water Flow}_{\text{Total}} = 700,000 \text{ gpm / unit}$$

$$E_{\text{Wet Summer}} = 11,690 \text{ gpm}$$

$$E_{\text{Hybrid Winter}} = 5,670 \text{ gpm}$$

$$D = 7 \text{ gpm}$$

$$B_{\text{Wet Summer}} = 2916 \text{ gpm}$$

$$B_{\text{Hybrid Winter}} = 1411 \text{ gpm}$$

$$M_{\text{Wet Summer}} = 14,612 \text{ gpm / unit}$$

$$M_{\text{Hybrid Winter}} = 7,088 \text{ gpm / unit}$$

Total plant makeup from the River, summer wet mode tower operation, good water quality, would hence equal =  $M_{\text{Wet Summer}} = 29,224 \text{ gpm}$

Total plant makeup from the River, winter hybrid mode tower operation, good water quality, would hence equal =  $M_{\text{Hybrid Winter}} = 14,176 \text{ gpm}$

The total range for makeup flow to the plant varies from a maximum of 35,070 gpm to a minimum of 14,176 gpm, depending on mode of operation of the cooling towers and River intake water quality. Although a pre-determined set flow rate correlating to worst case conditions could be maintained year around, use of automated control allows reduction of makeup flow by more than 50% under optimum conditions.

Condenser cleaning and maintenance w/ closed-loop cooling – Current plant design does not incorporate a condenser cleaning system. However, during the late fall, winter, and early spring months, any one of the three condensers on either unit can be removed from service for maintenance and/or tube cleaning while the operating unit is at full power. The temperature of the River intake water is sufficiently cold to remove the full unit heat load with only two of three condensers in service. This operating scheme will not be an available option with a closed-loop cooling system due to the appreciably higher condenser inlet water temperatures. During periods of very cold ambient conditions, when cooling tower supply to the condenser is at the lowest attainable temperatures, a condenser could be taken out of service, but only with an appropriate level of load reduction from the operating unit.

A better alternative is the installation of a condenser tube cleaning system. This provides two advantages:

- Eliminates the need to take a condenser out of service for tube cleaning.
- Allows maintaining the tubes at a consistently low level of fouling.

Since the presence of fouled tubes will have a greater impact on Station output once converted to closed-loop cooling, due to higher condenser inlet water temperatures, installation of a condenser tube cleaning system is an imperative part of the plant redesign. The design of the new circulating water pump house for each unit will thus incorporate the requirements for a permanently installed condenser tube cleaning system.

### 3.0 Economic Estimates

Included within this section are estimates of the costs of various aspects of the conversion of Indian Point Units 2 and 3 to closed-loop condenser cooling. The capital costs of the initial conversions are quantified, including design, procurement, implementation, and startup activities, based on the conceptual design previously identified and discussed. The duration of the required unit outages, based on a timeline of critical milestones that must be worked with the associated unit off-line, is utilized to determine the resulting lost generating capacity, expressed in  $MW_{\text{HOURS-ELECTRIC}}$ . The new cooling towers and circulating water pumps will require operations and maintenance personnel support, and service, repair, and replacement of components; based on input from potential supplying vendors, these costs are approximated. Additionally, the new towers and circulating water pumps require an appreciable amount of power to operate, herein referred to as “parasitic losses”, which effectively reduces Station output power to the distribution grid. Power consumption of the required new components can be estimated from preliminary vendor data, and hence total  $MW_{\text{ELECTRIC}}$  parasitic losses determined. Finally, the conversion creates less than optimum operating parameters for the existing turbine/condenser, resulting in reduced unit output to the grid under most operating conditions. Based on existing Station performance data, and applicable input from turbine/condenser modeling software provided in Attachment 3 (PEPSE), the reduction in unit performance, in generator output  $MW_{\text{ELECTRIC}}$ , is be provided.

#### 3.1 Initial Capital Costs

An accurate assessment of the capital costs associated with the proposed conversion is a critical goal of this Report. Minimizing assumptions, and relying instead on well-developed, detailed conceptual designs, greatly increases the accuracy of the ensuing estimates. In broad terms, conceptual design engineering outlined system scope definition, proposed detailed layout, equipment specification/criteria, and assisted in gathering some of the site-specific historical data. Attachment 2 to this Report includes some of the conceptual drawings utilized for subsequent construction estimates. This information was used to develop greater detail regarding associated tasks and logistics required as a minimum to successfully perform the construction for the conversion. The resulting Direct Capital Cost Estimate and Project Schedule represent well thought out approaches with a reasonable level of detail in order to generate a responsible and aggressive response.

The estimating basis relied less on theoretical national production rates and cost factoring and focused more directly toward soliciting the various assets capable of providing real world solutions. Trusted vendors were contacted for quotations on the major equipment and material components, while local contractor support assisted in developing the labor, equipment, and scheduling requirements. Attachment 1 to this Report includes vendor data and budgetary cost estimates for major equipment components. Few allowances were applied and only when time did not permit further task development or reasonable vendor contact and quotation. Nationally recognized consultants supported the evaluation and recommendation process for significant and or specialized operations to ensure practical and complete solutions.

The Direct Capital Cost Summary contained in Attachment 6 combines the data input from these resources with the defined scope of work to produce a straight forward analysis of cost and duration. The major cost centers were defined and presented in line item format in order to provide some flexibility in the application of cost. Some of these

line items will be equally shared by both ENIP 2/3 as common operations required to perform the scope of work based on the premise that both ENIP 2/3 will be required to make the conversion, hence if separated, these common cost would not simply be cut in half but more realistically apply to each individual Station.

The anticipated direct capital cost (presented in 2003 US dollars) for the conversion for both ENIP2 and ENIP3 is collectively estimated at a minimum of \$612 million without bonding the contractor, contingency application, or any escalation over time. Contractor bonding could add an additional cost of about \$4 million while recommended contingency application would add another \$123 million (based on RS Means and industry standard of 20% for conceptual estimates). The escalation of cost over the project schedule was not calculated as part of this report but represents a significant increase when calculated over the 5 year anticipated duration. Certain break-out costs are provided in Attachment 6 that justify the noteworthy cost drivers. Total estimated direct capital costs for the conversion is thus \$739,680,000.00.

Appendix 6B of Attachment 6 outlines the preliminary scheduling basis for this report. Considering the conceptual nature of the current design parameters and the unknown forces outside of the project's direct control, many of the tasks are aggressively optimistic and could be severely impacted as work progresses. Therefore, the context of the following is intended to bound the minimum duration required for the project. Design engineering is assumed to begin at or about January 2005 and continue through December 2008. Anticipated construction start is in June 2005 based on having all permitting and licensing requirements in place prior to starting. Work will begin on Unit 2 in July 2005 with Unit 3 phased shortly thereafter in October 2005. Construction work and field engineering will continue in tandem up and through the recommended outage period beginning in March 2009 and extending for 10-11 months to February 2010. Total duration of the forced outage is estimated to be 42 weeks.

There were some necessary assumptions, where the final outcome of the associated issues could affect the conclusions of the Report. This Report is grounded on the assumption that Algonquin Pipeline, a division of Duke Energy, completes its independent assessment and concludes that the siting of the cooling towers, as contemplated in this Report, is acceptable to Algonquin under the existing easement agreement and otherwise. ENIP2 and ENIP3 have not received information from Algonquin regarding Algonquin's conclusion, or on the costs and technical requirements on which Algonquin may insist assuming that any such siting is acceptable. However, we anticipate that costs will be significant, particularly if Algonquin require relocations of the line, as is likely. We also anticipate that Algonquin would insist that ENIP2 and ENIP3 solely bear any such costs or expenses. Hence, an assumed cost of relocating the pipeline, based on input from another pipeline constructor, was utilized in construction cost estimates. Of course, Algonquin's estimated cost could fundamentally alter the cost assessment in this Report and, therefore, its conclusions. Further, if Algonquin completes its independent assessment and concludes that such siting is not acceptable, the siting of the cooling towers, as contemplated in this Report, is unlikely to remain technically feasible at any cost. As such, we must retain a full reservation of rights to amend or modify this Report to reflect Algonquin's decision.

Other issues that represent potentially severe cost and schedule impacts are discussed in Attachment 6 and not included in the above cost or schedule considerations. Some of these issues include but are not limited to:

- Regulatory Agency Interactions
- Public Perceptions of Blasting and Heavy Construction Activities
- Elevations in Homeland Security Levels
- Resource Availability (material, equipment, and most specifically craft labor)
- Large Volume of Spoils and Construction Debris Disposal
- Outside Power Tie-in and Availability through Con-Ed
- Riverside Activities and Potential Maritime Implications
- Unpredictable Weather Phenomena

The above concerns are not all inclusive but represent some major challenges that the construction team must focus on from the beginning and throughout the conversion. It is difficult to determine exact cost impacts or ranges thereof at this point based on probability or severity of the issue involved, but any impact would tend to increase overall costs.

### 3.2 Lost Generating Capacity During Implementation

From the construction schedule provided in Attachment 6, Appendix 6B, the approximate duration that Units 2 and 3 will be in a forced outage to accommodate the conversion to closed-loop cooling is 42 weeks. This represents optimum performance during the construction phase, with no contingencies or allowances for emergent activities or overruns, and assumes the maximum possible portion of the work scope being performed either pre-outage or post-outage.

A typical refueling outage for either Indian Point unit has a duration of 24 to 28 days, and the outages are performed out of phase, to minimize impact on the power grid. For purposes of this Report, it will be assumed that 4 weeks of the forced outage for the conversion will be utilized for refueling of both units. The remaining 38 weeks conservatively represent a period of lost generating capacity for the Station.

Estimating the lost generating capacity from a 38 week outage, based on a typical IP2 generator output of 1015 MW<sub>E</sub> and IP3 generator output of 1035 MW<sub>E</sub>:

Indian Point 2, 6.48 million megawatt hours

Indian Point 3, 6.61 million megawatt hours

Although generating capacity as well as wholesale cost of electricity vary, the approximate dollar cost of the outages, based on \$48.00/MWh projected short-term cost equates to:

Indian Point 2, \$311 million

Indian Point 3, \$317 million

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3.3 Operational and Maintenance (O&M) Cost

Additional Station O&M costs for the components added due to the conversion to closed-loop cooling can be best estimated by identifying the general tasks for each component, and then based on operational experience and input from vendors, quantifying the estimated required man-hours and associated costs.

Although the conversion to closed-loop cooling is complex, significant new/modified plant components are limited to the cooling towers with their fans and booster pumps, and the appreciably larger circulating water pumps located in new pumphouses downstream of the condensers.

Operational Support Cost

The tower selected for Units 2 and 3 is a Marley/Balcke-Durr round hybrid tower, designed with noise and plume abatement features. The hybrid design uses 44 wet section fans with motor output power of 300Hp and 44 dry section fans with motor output power of 350Hp. In addition, the dry section of the tower requires the addition of two booster pumps, each with a flow capacity of 122,500 gpm @ 26ft TDH. The pumps will run using approximately 250Hp while the dry section of the tower is required to be in operation for plume abatement. Due to the large number of active components, as well as the sheer size of the towers and their hot water distribution system, appreciable Operations support is anticipated. For purposes of this assessment, chemistry personnel (for water quality maintenance) man-hours are included/encompassed under Operations.

The anticipated manpower required for operational support of each cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Daily	<ul style="list-style-type: none"> <li>• Check fans, motors, driveshafts, gear reducers</li> <li>• Check gear reducer oil level</li> <li>• Check electrical substation, transformers, switchgear</li> <li>• Monitor local control panel and alarm displays</li> <li>• Check water level in cold water basin and hot water distribution system</li> <li>• Check booster pumps and associated instrumentation</li> <li>• Sample water quality</li> </ul>	Ops	
Cost Basis	8 hrs/day X 12 months		\$146,000.00
Weekly	<ul style="list-style-type: none"> <li>• Inspect hot water distribution system</li> <li>• Inspect fill for fouling</li> <li>• Check gear reducer for leakage</li> <li>• Adjust water quality</li> </ul>	Ops	
Cost Basis	40 hrs/week X 12 months		\$105,000.00
Notes: Cost based on O&M labor estimates of \$50/hour (hourly wage + benefits)			

Manpower cost for operation of the new pumping station should be the same as for the current pumping station, therefore no cost increases were assumed.

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Based on the above identified anticipated tasks, applied to Indian Point 2 and Indian Point 3, annual additional Operations support for the closed-loop configuration is estimated to be \$251,000.00 for each Unit.

Maintenance Cost

The anticipated cost for preventive and corrective maintenance, including both labor and parts, of each cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Monthly	Inspect drift eliminators and fill for clogging Check gear reducer oil seals, oil level, and oil condition	Maint.	
Periodic (Quarterly estimated)	Clean and repaint fans and drivers, drift eliminators, fill, hot water distribution system Rebalance fans and driveshafts Lighting inspection or replacement	Maint.	
Semi- annual Inspection	Inspect keys, keyways, set screws & tighten bolts for fans and drivers Change oil and check vent condition for gear reducers Check fan blade clearances Check for leakage in fill, basin and hot water distribution system Inspect general condition and repair as necessary all tower components including cranes and hoists	Maint.	
Annual Inspection and Corrective Maint.	Inspect general condition of basin, suction screen and tower casing Inspect/repair fans and drivers, and tower access components, including stairs, ladders, walkways, doors, handrails Transformer Inspection Starting at year 16, replacement of fan blades, fan motors, fan gearbox, fill, drift eliminators	Maint.	
Quarterly	Lighting Inspection or Replacement	Maint.	
	Annual maintenance cost estimate (years 1-5)*		\$500,000.00
	Annual maintenance cost estimate (years 6-15)*		\$1,000,000.00
	Annual maintenance cost estimate (years 16-20)*		\$2,000,000.00
Notes: *Based on vendor (Marley Cooling Tower) estimates/historical data			

Maintenance cost for the new pumping stations, based on utilizing the same number of pumps and appreciably the same flow rates as existing, remain virtually the same. Therefore, no additional initial/routine pumping station maintenance cost was assumed for this study.

Long-term rehabilitation and replacement costs include those costs for replacement of components such as pump impellers, motors, or entire assemblies. Major equipment rehabilitation or replacement is usually estimated to occur between 20 to 40 years after

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placing the equipment into operation. Rehabilitation costs for major equipment can be estimated to be 35 to 45 percent of replacement costs depending of the condition of the equipment. Other items of equipment may be replaced several times during the plant life, depending on their use, or may require only partial replacement. It is most likely that equipment, except for pump and motor, may not be replaced in kind. Therefore, the replacement cost should include all engineering and structural modification costs as well as the equipment costs [Reference 5.11].

Based on remaining plant life it was assumed that 1/2 of the pumps (3 pumps, @ approximately \$800,000.00/pump) would require rehabilitation or partial replacement. When including other miscellaneous pumping station components, the estimated rehabilitation and replacement cost for one pumping station is approximately \$1,500,000 for an assumed remaining plant life of 30 years. Hence, on an average annual basis, beginning at year 16, pumping station maintenance costs would increase by \$100,000.00/pumping station.

Summary of Additional O&M Cost (per year, per Unit cost)

Years 1-5	\$751,000.00
Years 6-15	\$1,251,000.00
Years 16-30	\$2,351,000.00

### 3.4 Parasitic Losses (Costs) Attributable To New Components

A computer simulation of the High and Medium Voltage Electrical Distribution System was created based upon estimated fan and pump horsepower requirements for the selected hybrid towers and new circulating water pumphouses. The model utilizes ETAP® PowerStation® software from Operation Technology, Inc. ETAP PowerStation is an integrated analysis tool used to design, maintain, modify, and operate electric power systems. Attachment 7 provides the single line diagrams and output reports obtained from computer simulation runs.

The information used for simulating the existing distribution demands and configuration was taken from Indian Point 2 calculation FEX-0143-00. The values of impedance and Thevenin equivalence for the Buchanan 138kV Switchyard and overhead distribution cables were found in the electrical distribution model, and the values for existing demand on the Unit 2 Station Auxiliary Transformer was provided in Attachment E of the IP2 calculation. Because FEX-0143-00 only models Indian Point Unit 2, the assumption was made that Unit 3 would have an equivalent distribution and demand; for purposes of determining electrical demand, this approximation is reasonable.

For modeling new components when vendor data for motor efficiencies and power factors is not provided, ETAP PowerStation provides industry standard data which allows reasonably precise approximations. All fan motors, booster pump motors, and circulating water pump motors were modeled using the ETAP PowerStation industry standards.

The circulating water pumps are a constant load; i.e., there are no operational variations in power consumption, all six pumps/unit operate at full capacity at all times. To address the added circulating water pump load due to the conversion to closed-cycle cooling, the

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power requirements of the existing pumps are simply subtracted from that of the pumps required for the closed-loop configuration.

Unit	Combined Electrical Load, Six Pumps		Additional Parasitic Losses (Pump Power)
	Existing Configuration	Closed Loop	
2	4.50 MW	13.47 MW	8.97 MW
3	4.50 MW	13.47 MW	8.97 MW

For the hybrid cooling towers, the computed results for maximum normal load, occurring during daytime winter operation with both wet and dry sections of the tower at full power, shows that the electrical power load for each tower is approximately 24MW. This load represents a corresponding parasitic loss to the output of each of the Stations. However, the load resulting from the towers varies significantly due to ambient environmental conditions. When operating only in the wet mode, during summer conditions and at night, the cooling towers require approximately 10.5 MW each, less than half the power required during winter daytime conditions.

Site meteorological data from 1998 to 2000 was utilized to determine average monthly wet bulb temperatures. Based on the average wet bulb temperature, the tower dry section utilization can be approximated; i.e., the percent of the time the dry section fans and booster pumps are operating, and hence the approximate monthly MW power usage rate.

$$\text{Tower Usage}_{\text{Each Tower}} = \text{wet section MW} + [(\text{usage \%})(\text{dry section MW})]$$

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. WB (°F)	27.5	30.9	34.7	41.2	50.6	58.3	64.0	63.2	57.6	47.5	39.6	31.6
Usage (%)	70	70	60	50	50	40	30	30	40	50	60	70
U2 Usage (MW)	20.0	20.0	18.6	17.3	17.3	15.9	14.6	14.6	15.9	17.3	18.6	20.0
U3 Usage (MW)	20.0	20.0	18.6	17.3	17.3	15.9	14.6	14.6	15.9	17.3	18.6	20.0

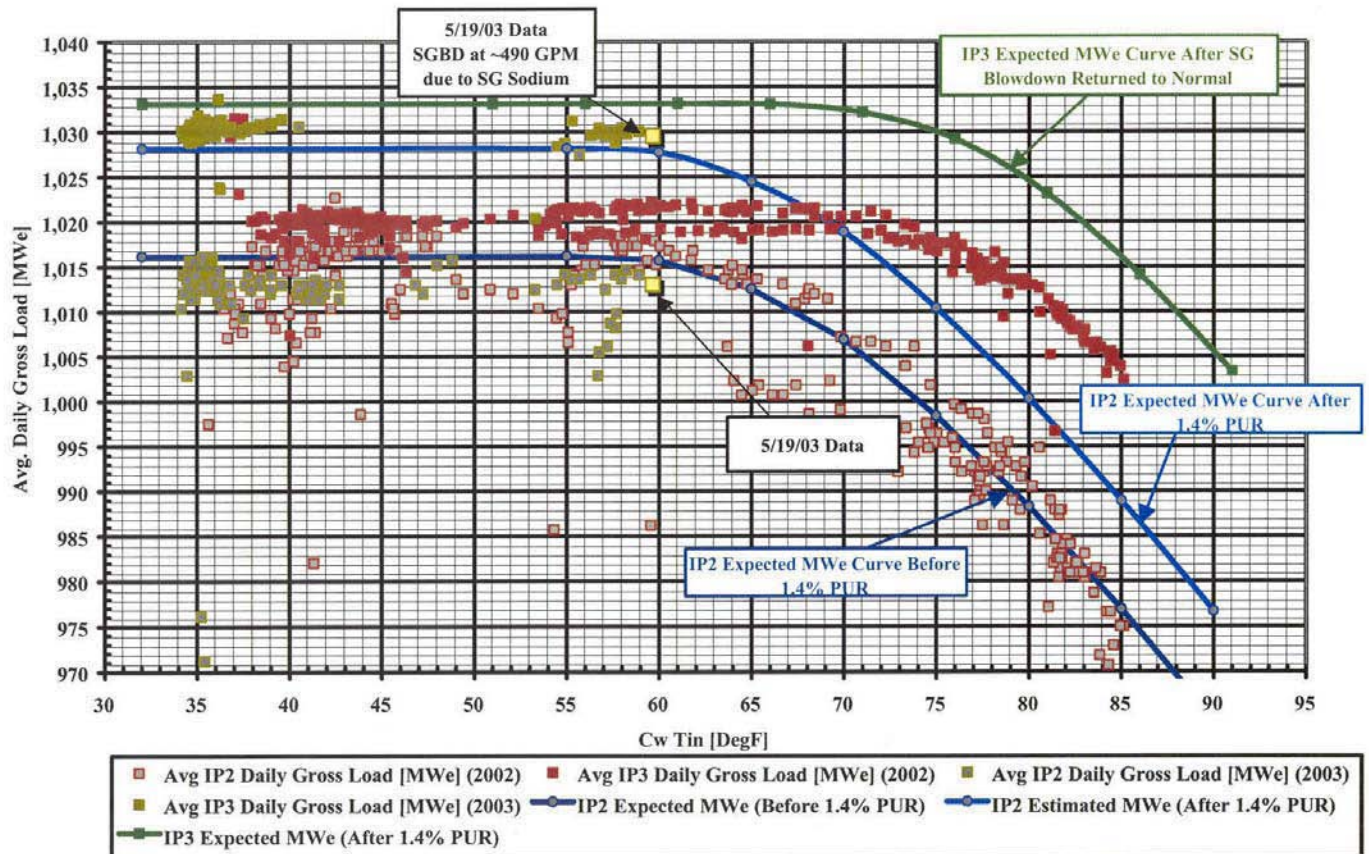
Based on the estimated power requirements of the new circulating water pumps, and the above tabulated estimated monthly power requirements for the hybrid towers, the total average monthly parasitic losses due to conversion to closed-loop cooling is as follows:

$\text{Indian Point Unit 2} = 8.97 \text{ MW}_{\text{Circ. Water Pumps}} + 17.51 \text{ MW}_{\text{Tower Avg.}} = 26.48 \text{ MW}_{\text{Avg. Loss}}$ $\text{Indian Point Unit 3} = 8.97 \text{ MW}_{\text{Circ. Water Pumps}} + 17.51 \text{ MW}_{\text{Tower Avg.}} = 26.48 \text{ MW}_{\text{Avg. Loss}}$
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### 3.5 Costs Due To New Condenser Operating Parameters

The following graph, taken from actual plant performance data demonstrates the effect of increased circulating water inlet temperature ( $CW T_{in}$ ), on gross unit output ( $MW_E$ ), for Indian Point 2 and Indian Point 3 during operating years 2002 and 2003. Additional data and discussion of plant performance versus condenser inlet temperature are included in Attachment 3.

Figure 3.1 – Average IPEC  $CW T_{IN}$  / Average Daily Gross Load



As the graph clearly shows, when circulating water inlet temperatures increase, the plant gross output decreases. For Indian Point 2 the decrease in output begins as circulating water temperatures increase beyond approximately 60°F, and drop dramatically as circulating water temperatures increase beyond 70°F. For Indian Point 3, the output remains relatively constant until circulating water temperatures increase beyond 70°F.

The loss of output is due to increased condenser backpressure on the turbine. Indian Point 2 has a differently designed low pressure (LP) turbine than Indian Point 3, this accounts primarily for the increased losses at elevated River water temperatures for Indian Point 2 versus Indian Point 3; i.e., the Indian Point 2 turbine is more sensitive to, and less efficient with, increased backpressure. Figures 3.2 and 3.3 (generated via PEPSE software) indicate the relative impact of River water temperature on condenser backpressure for each unit.

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Figure 3.2 – Indian Point 2 Condenser Pressure vs. River Water Temperature  
 (100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)

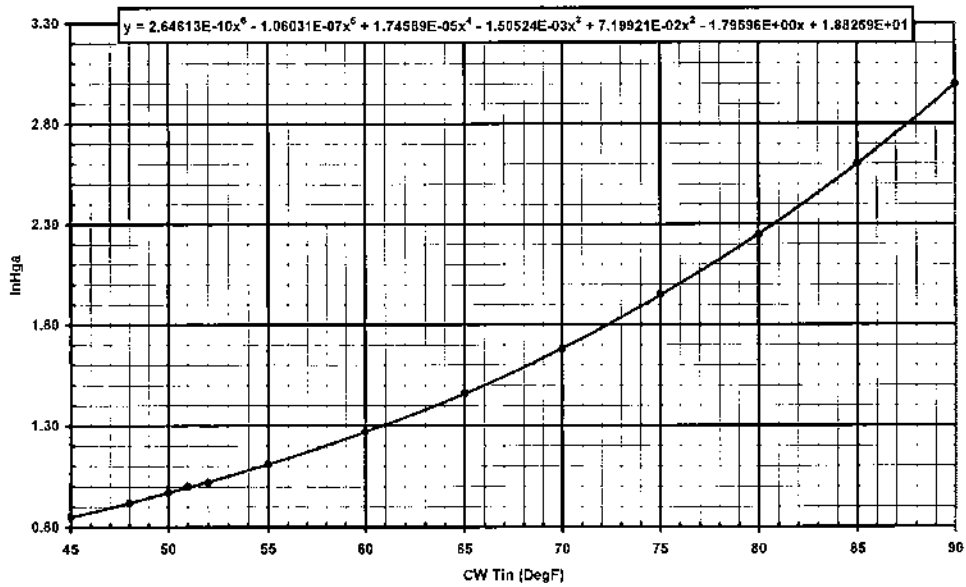
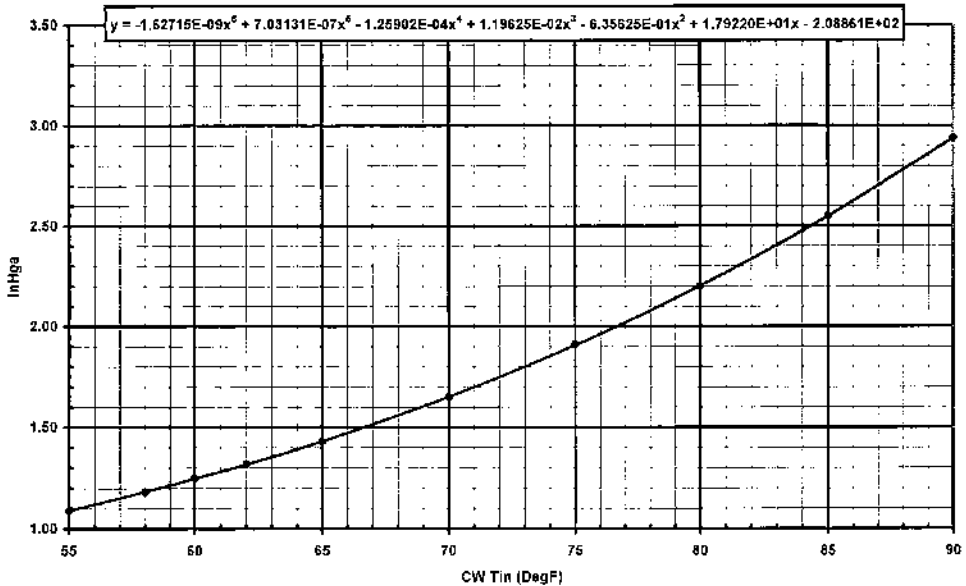


Figure 3.3 – Indian Point 3 Condenser Pressure vs. River Water Temperature  
 (100% Power, 80% Condenser Clean, 1 DegF Condensate Subcooling, 380 RPM CW Pump Speed)



Comparing the above graphs, it is evident that the condensers respond virtually the same to River water temperature changes:

River Water Temperature (°F)	Pressure (InHga), Unit 2 / Unit 3
60	1.28 / 1.26
70	1.69 / 1.66
80	2.25 / 2.20
90	3.00 / 2.95

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Figures 3.4 and 3.5 indicate the relative impact of river water temperature on generator output for each unit.

Figure 3.4 – Indian Point 2 Generator Output vs. River Water Temperature

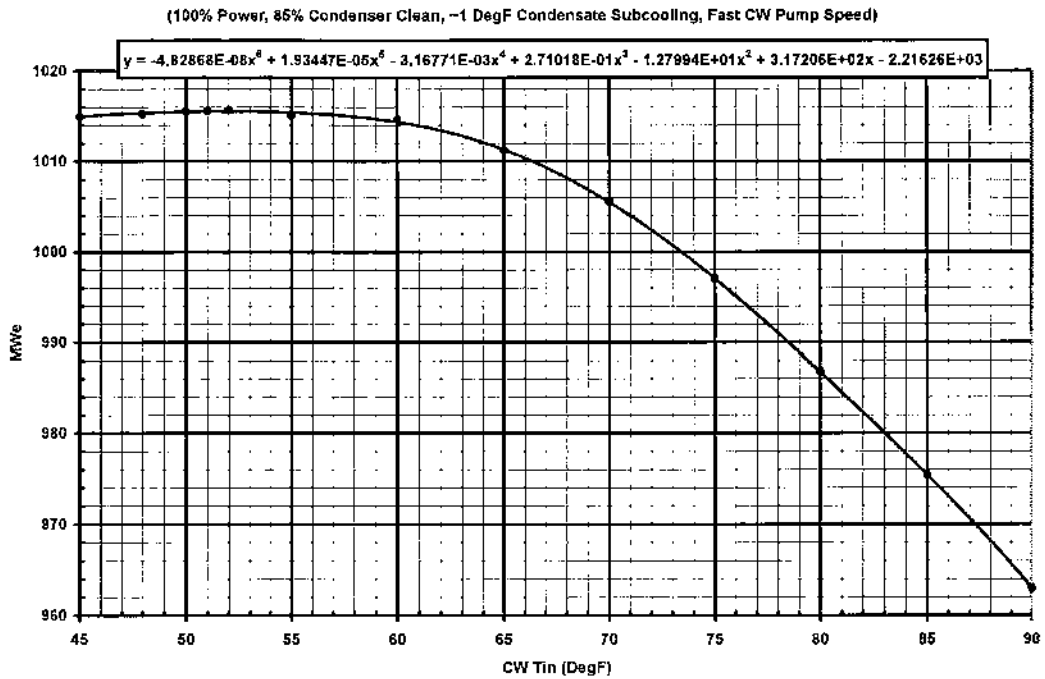
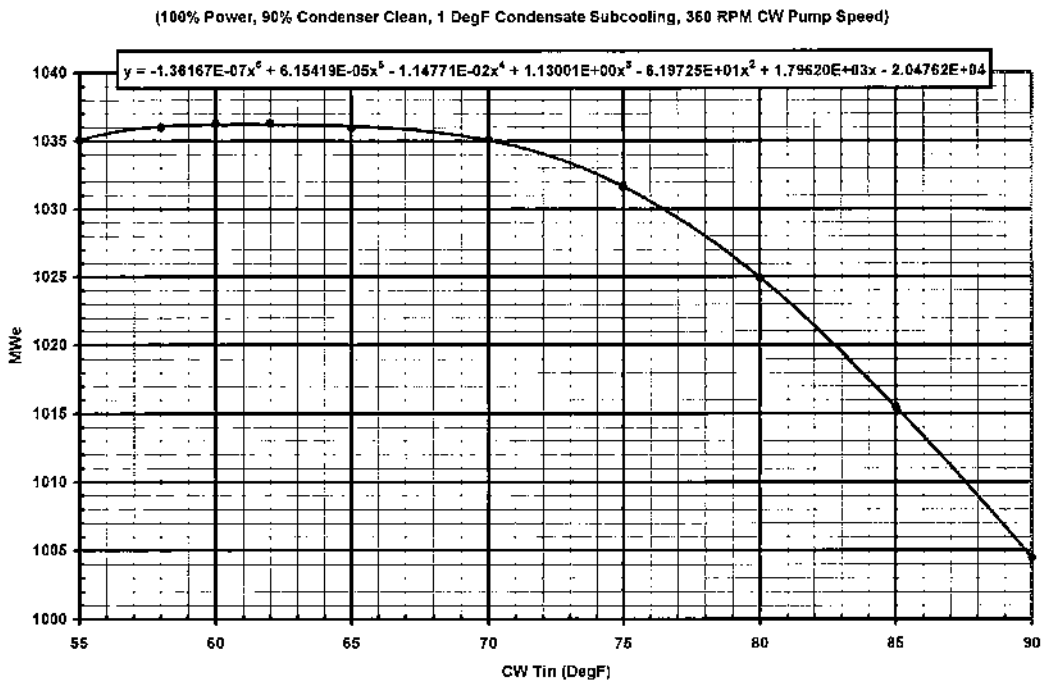


Figure 3.5 – Indian Point 3 Generator Output vs. River Water Temperature



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The difference in generator output vs. river water temperature for each unit is evident. Due to the differently designed turbine in Indian Point Unit 2, significant losses in generator output occur at appreciably lower River (condenser inlet) water temperatures.

Attempting to quantify the potential maximum loss of output, the estimated power reduction on a per unit basis is as follows;

Indian Point 2 – Unit gross output, at circulating water temperatures less than 60°F, is approximately 1015 MW<sub>E</sub>. Unit gross output, at circulating water temperatures approaching 88°F, is approximately 968 MW<sub>E</sub>. Although the data points have some degree of variance, as the circulating water temperature increases from 60°F to 85°F, the unit output decreases from 1015 MW<sub>E</sub> to 968 MW<sub>E</sub>, a net decrease of approximately 47 MW<sub>E</sub>.

Indian Point 3 – Unit gross output, at circulating water temperatures less than 70°F, is approximately 1036 MW<sub>E</sub>. Unit gross output, at circulating water temperatures approaching 88°F, is approximately 1009 MW<sub>E</sub>. Although the data points have some degree of variance, as the circulating water temperature increases from 70°F to 85°F, the unit output decreases from 1036 MW<sub>E</sub> to 1009 MW<sub>E</sub>, a net decrease of approximately 27 MW<sub>E</sub>.

Specifically as applies to the Indian Point plant condenser design, conversion to a closed-loop cooling configuration, with cooling towers as the vehicle for heat rejection, creates inherent limitations relative to plant performance. Whereas the Hudson River provides very cold water much of the year, consistent with the design requirements of the current condenser/turbine combination, a cooling tower is limited by the mechanism of evaporative cooling. Design of a cooling tower involves a trade-off between achievable cold water temperature, governed by approach to the maximum wet bulb temperature, and the size and cost of the tower.

For the Indian Point site, an appropriate design maximum wet bulb (reached/exceeded 0.4 % of the year, based on ASHRAE data for Newburgh, NY) is 76°F. The performance of a cooling tower is limited by the “approach” to design wet bulb temperature (see Figure 3.6). For instance, a tower designed for a 15°F approach will produce 91°F cold water when the design wet bulb of 76°F occurs (15+76=91). An appreciably (30%) larger tower, designed for a 12°F approach, would produce 88°F cold water at the same design wet bulb.

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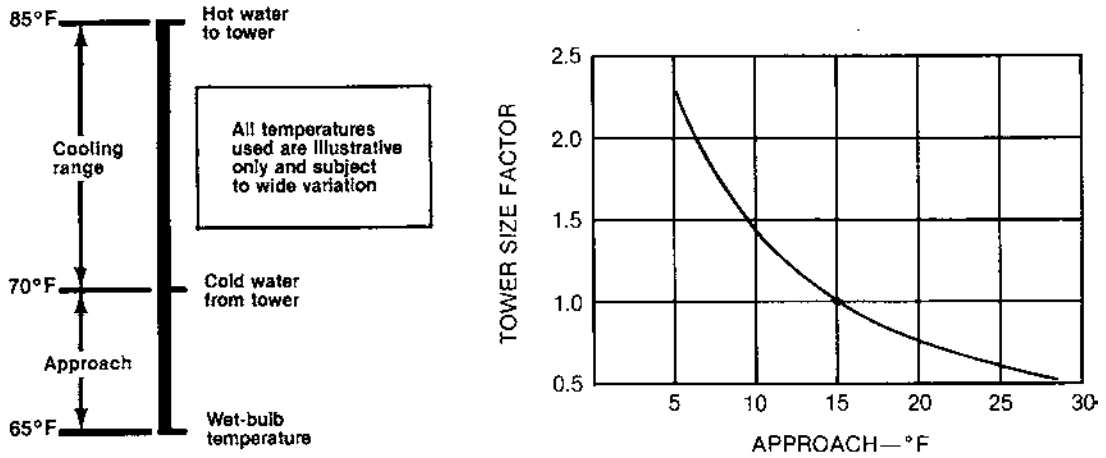


Figure 3.6 – Definition of “Approach,” “Cooling Range,” and relationship of approach to tower size [Reference 5.4].

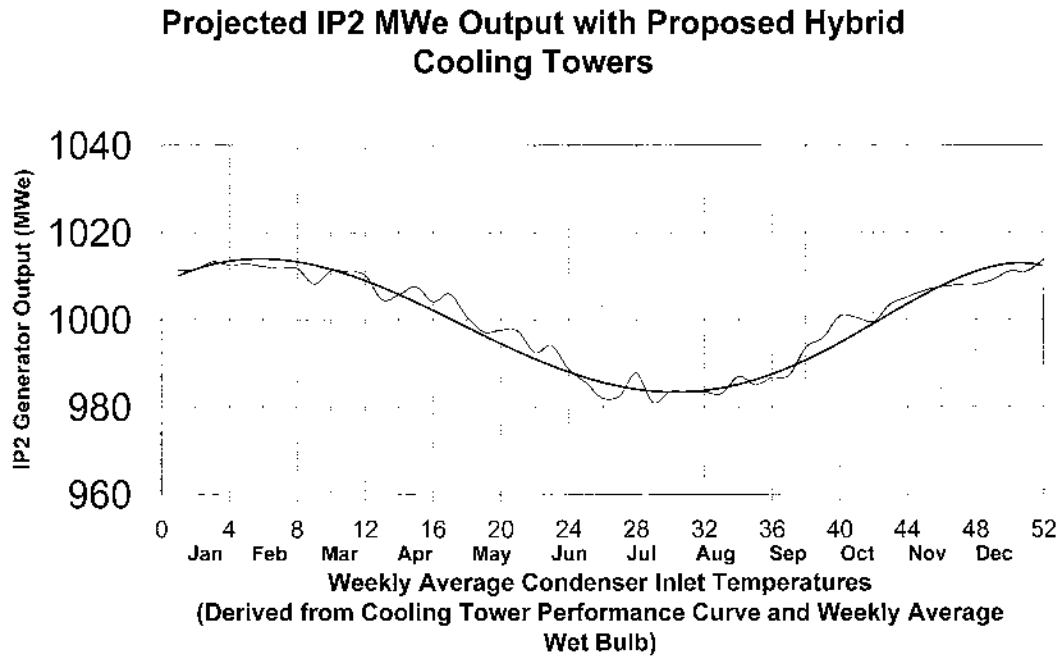
The graph on the left shows the relationship of range and approach as the heat load is applied to the tower. Although the combination of range and gpm is fixed by the heat load in accordance with  $\text{Heat Load} = \text{gpm} \times 8.33 \text{ lbs./gal. water} \times \text{range} = \text{Btu/min.}$ , approach is fixed by the size and efficiency of the cooling tower.

The graph on the right indicates how given two towers of equal efficiency, with proportionate fill configurations and air rates, the larger tower will produce colder water; i.e. have a closer approach. Important to note, from a tower cost standpoint, is the fact that the base 15°F approach tower would have had to be twice as large to produce a 7°F approach, whereas it could have produced a 25°F approach at only 60% of its size.

For the application at Indian Point, the Marley Cooling Tower Company was consulted relative to optimum tower design approach and tower sizing. Largely due to site specific restrictions and the need to utilize a hybrid tower, a tower with a 12°F approach was considered the largest that could be effectively utilized. Even with the approach limited to 12°F, the required tower would be approximately 525 feet in diameter, and would require (44) 300 HP motors for the wet section, and (44) 350 HP motors for the dry section. Since the 88°F condenser inlet water will only occur at maximum ambient conditions, and the wet section fan parasitic losses occur continuously, the 12°F approach tower design point was considered the optimum trade-off between total capacity and performance, and size, initial cost, and operating costs.

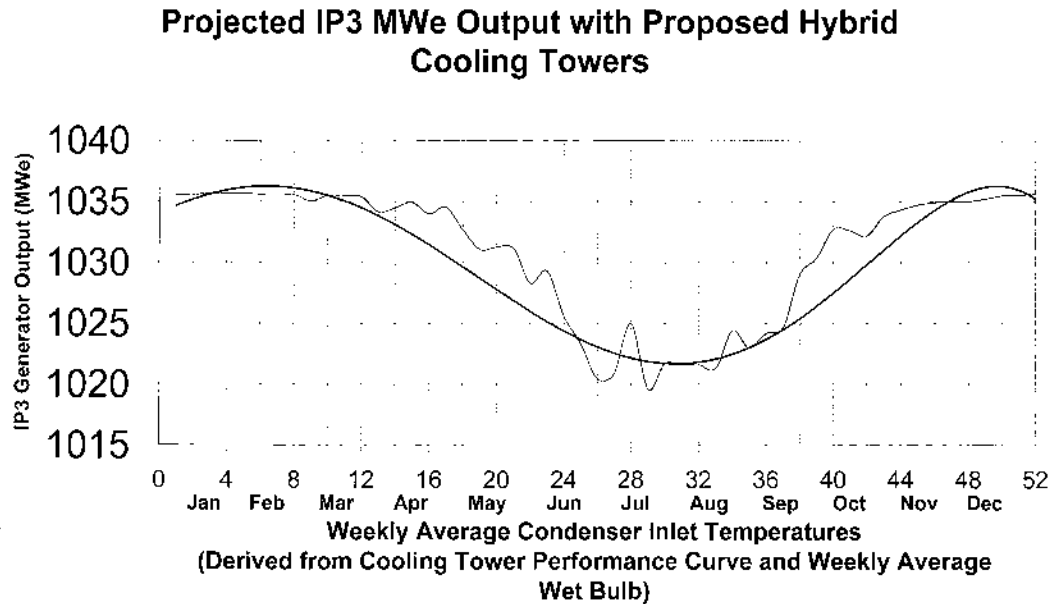
The following Indian Point 2 and 3 output curves will provide a basis for estimating post-closed-loop conversion monthly Unit output, via plotting condenser inlet (cooling tower outlet) temperature based on monthly mean wet bulb temperature, with the corresponding average monthly Unit output.

Figure 3.7 – IP2 Average Monthly Generator Output w/ Hybrid Cooling Towers



The weekly average wet bulb temperature is based upon Station meteorological data over the period of 1998 through 2000. This data is utilized to derive the corresponding weekly average condenser inlet temperature for each unit, based on the cooling tower performance curves for the proposed hybrid towers [Attachment 1, Marley Data].

Figure 3.8 – IP3 Average Monthly Generator Output w/ Hybrid Cooling Towers



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By determining the impact on each operating unit's output on a weekly basis throughout the year, based on average ambient conditions, the resulting average annual impact can be estimated for each unit.

Indian Point 2 – Whereas the impact on unit output at maximum ambient conditions was previously estimated to be 47 MW<sub>E</sub>, the estimated reduction on an annual basis is 15 MW<sub>E</sub>; i.e., the annual average generator output with closed-loop cooling, utilizing the proposed hybrid cooling tower, is 1000 MW<sub>E</sub>.

Indian Point 3 – Whereas the impact on unit output at maximum ambient conditions was previously estimated to be 27 MW<sub>E</sub>, the estimated reduction on an annual basis is 6 MW<sub>E</sub>; i.e., the annual average generator output with closed-loop cooling, utilizing the proposed hybrid cooling tower, is 1030 MW<sub>E</sub>.

Attachment 3 includes all condenser performance data upon which these assessments and conclusions are based. Both compilations of previous actual turbine/condenser and unit output performance, as well as analytical projections based on PEPSE computer software are included.

In summary, generator output at peak (maximum ambient temperature) load conditions, following closed-loop conversion:

Indian Point 2, 968 MW<sub>E</sub>, a reduction of 47 MW<sub>E</sub>

Indian Point 3, 1009 MW<sub>E</sub>, a reduction of 27 MW<sub>E</sub>

Average annual generator output, following closed-loop conversion:

Indian Point 2, 1000 MW<sub>E</sub>, a reduction of 15 MW<sub>E</sub>

Indian Point 3, 1030 MW<sub>E</sub>, a reduction of 6 MW<sub>E</sub>

### 3.6 Water Treatment Costs

The existing once-through circulating water cooling system receives a minimum of water treatment. Biocides, specifically sodium hypochlorite, are added in quantities to achieve resulting concentrations as allowed by the discharge permit to minimize fouling of the condensers. Annual costs of these biocide injections are estimated to be less than \$50,000.00.

With a closed-loop cooling system, water treatment requirements are dramatically increased. The cooling tower fill is subject to fouling, as are the dry heat exchanger sections. Both the quantities and frequency of biocide injections must be increased significantly to maintain the tower fill in proper condition.

Additionally, increased water treatment is necessary due to the higher concentrations of dissolved solids, chemicals, and biological agents in the system resulting from constant recirculation of the condenser cooling water. The cooling towers act as air washers as well as distilleries, constantly evaporating large quantities of water and leaving behind the non-volatile residues. The actual concentrations of these agents is wholly based on the cycles of concentration (cycles of concentration is discussed in section 2.3 of this Report), which are being used in the circulating water system.

Unlike the simple injections of biocide required for the once-through configuration, a closed-loop configuration typically utilizes a veritable cocktail of chemicals, each with

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specific attributes. Chemical treatment is broken into three subsections, deposition, corrosion, and biological.

#### Deposition

There are two forms of deposition, one being sedimentation, which is usually mitigated through piping design and the second being scaling. Scaling is a complicated condition and requires a educated approach to mitigation. In some cases scaling is necessary and useful in a piping system to prevent corrosion. For example a thin uniform coating of calcium carbonate provides corrosion protection for internal surfaces of piping, therefore this type of scaling is desirable and should be left intact where possible. The major problems arise when scaling becomes to thick and reduces heat transfer with the condenser or cooling tower. Scaling is kept under control through the use of pH control and dispersants.

#### Corrosion

Corrosion control is a complex science, requiring considerable knowledge of corrosion chemistry and of the system being evaluated. Corrosion is best mitigated through piping design and an aggressive chemical treatment program using pH control and corrosion inhibitors.

#### Biological

Biological growth or biofouling is the most difficult chemical challenge to a cooling water system since it involves a dynamic biological process. The biological process also promotes corrosion through the breakdown of chemical components and the creation of localized acids. In a closed-loop where the concentration of nutrients has increased, biofilms tend to increase on the piping internal surfaces and cooling tower fill. Control of the biofilms usually involve combining biocides with surfactant-type biodispersant to disrupt the biomatrix, allowing better penetration of the antimicrobial. Additional chemical treatments such as biodetergents may also be necessary depending on local biologicals and conditions.

Major cooling water chemicals would typically include:

<u>Chemical type</u>	<u>Use/Function</u>
sodium hypochlorite	biocide
surfactant	biocide aid
sulfuric acid	PH control
dispersant	scale prevention
phosphate	corrosion control

Appreciably increased costs are associated with this increased level of water treatment. Local conditions can greatly affect annual costs, but an annual cost per unit of \$750,000.00 would be extremely conservative. Total Station costs would therefore be estimated at \$1,500,000.00, and could easily approach \$2,000,000.00.

#### 4.0 Environmental Considerations

Based on the selected conceptual design, this section will identify, qualify, and quantify to the extent possible, resulting environmental impacts. Considerations and evaluations will include not only the long term positive and negative benefits, but also those interim impacts occurring during the implementation phase of the conversion.

Although resulting changes to the river intake flow will be quantified and specifically addressed in detail, the associated effect on entrainment and impingement of aquatic organisms is not included in this work scope, but rather is specifically addressed in a separate report.

##### 4.1 Cooling Tower Plume

The potential environmental impacts attributed to the proposed cooling tower plume can be categorized as visual impact and physical impact.

The cooling tower type selected, the round hybrid tower, has specific attributes that minimize the visual impact of the tower's plume. Also termed a plume abated tower, the selected model generates no visible plume under the conditions for which it is designed, which correlates to 90% of the projected operating conditions. The selected design "plume point" is 27°F @ 90% relative humidity; i.e., the plume will start to become visible when the design plume point is exceeded, although the plume will be much less dense and/or persistent than if generated by a non-plume-abated tower. Additionally the dry section of the tower would be secured at night when plume visibility is not an issue, eliminating the considerable power consumption of the associated (44) 350 HP fans.

The potential physical impacts from a tower plume arise primary from the moisture content, which can cause icing and fogging during winter conditions, the salt content of the entrained moisture (the water vapor in the plume contains no salt) which can damage vegetation, and the heat content, which could potentially degrade Station heating, ventilating and air conditioning (HVAC) systems. It is important to note, that a hybrid tower produces an invisible plume, however, the plume still exists.

##### Predicted Plume Travel

As previously discussed, the round hybrid tower has inherent advantages relative to the tower plume generation and path of dissipation. To best identify plume path and trajectory, a computer code can be utilized to model the plume under site typical environmental conditions. The behavior of the plume was modeled using the SACTI code under environmental conditions typical of Indian Point. The details of this modeling effort are contained in Attachment 5 to this Report. The results of the modeling effort are summarized below.

The model predicts that the visible plumes will be short, despite the conservative saturated assumptions; i.e., assumes non plume abated "wet mode" operation only. Model output data and subsequent tabulation shows the annual length versus frequency result. The plume length is 800 m or greater only 10.5% of the time, and plumes from one tower reach the other tower only 4% of the time (when the wind is either north or south and the length is at least 800 m). These are based on 100% wet operation, so use of the hybrid dry operation will eliminate the visible plumes during daylight hours on most days.

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Model output data also shows that the predominant direction of plume travel will be up or down the Hudson River (north or south), as would be expected with the prevailing winds. This effect also minimizes the inaccuracy introduced by lack of terrain modeling.

Drift and Salt Deposition

Drift is entrained water, in the form of small droplets, that exit the top of the cooling tower. When brackish water is used in evaporative cooling towers, salt dissolved in the drift may produce adverse effects on vegetation. The cooling towers proposed for Units 2 and 3 have a drift rate of 0.001%. This amounts to .00001\*700,000 gpm of water evaporated = 7 gpm for each tower.

The predicted salt deposition from a single tower is shown via model output data. The predicted deposition rates of up to 73 kg/km<sup>2</sup> per month compare with ambient natural local deposition rates measured at an annual rate of 16 µg/cm<sup>2</sup>month, which is 160 kg/km<sup>2</sup>month [Reference 5.5. ]

The predicted combined salt deposition from operation of both cooling towers is also demonstrated via the output data. The two-tower results show high deposition, approximately 112 Kg per Km<sup>2</sup> per month in the region between the towers, but still only on the order of the natural ambient deposition rate.

The description of potential injury to native trees in the immediate vicinity of Indian Point and to several food crops is presented in Table 4.1. Salt deposition from the cooling towers will combine with the natural deposition and may cause increased injury to hemlocks, dogwood, and white ash trees in the vicinity of Indian Point, however, the increased injury attributable to the operation of the cooling towers would be minimal.

Table 4.1. Potential Botanical Injury as a Function of Total Saline Deposit on Foliage

NaCl Deposit (Kg/Km <sup>2</sup> )	Potential Injury
0 to 40 <sup>1</sup>	No injury
40 to 100 <sup>1</sup>	All hemlocks show signs of injury 5 to 50% of dogwood and white ash develop slight leaf spotting and some loss of fall color.
100 to 600 <sup>1</sup>	All hemlocks, dogwoods, and white ash injured
> 600 <sup>1</sup>	All hemlocks, dogwoods, and white ash injured 20 to 80% of silk trees, forsythia, chestnut oak, black locust, white pine, red pine, and red maple show signs of injury
660 per month <sup>2</sup>	Tomato and pepper plants show signs of injury
2037 per month <sup>2</sup>	10% reduction in corn yield
6,908 per month <sup>2</sup>	No reduction in yield of alfalfa and cantaloupe crops

<sup>1</sup>Source: [Reference 5.2, and 5.12]] This information is based on laboratory experiments to determine botanical toxicity of salt deposition on vegetation typically found in the Indian Point area

<sup>2</sup>Source: [Reference 5.13]

Fogging and Icing

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The results of the modeling show that the plumes are not expected to circulate to the ground, primarily because of the high release height of the towers combined with the high velocity forced exiting airflow. Thus no plume fogging or icing is expected in the vicinity of Indian Point attributable to the operation of the cooling towers.

#### 4.2 Cooling Tower Noise

An ambient sound monitoring program was conducted in the vicinity of Indian Point 2 and Indian Point 3 between September 2001 and January 2002 [Reference 5.14]. Ambient noise levels were determined for seven representative sound receptor locations (Figure 4.1).

Existing sound levels at these locations are provided in Table 4.2.

Table 4.2: Average Measured Sound Levels (dBA)

Location	Daytime			Late Night		
	L <sub>90</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>90</sub>	L <sub>10</sub>	L <sub>eq</sub>
Saint Patrick's Church	41	50	48	42	48	46
16th Street / Broadway	38	51	50	40	46	45
Pheasant's Run	36	47	45	36	44	42
Town Hall	44	59	55	38	45	46
Bleakley Avenue / Broadway	45	61	58	38	44	42
China Pier	51	55	54	N/A	N/A	N/A
Theodore Hill Jr. Training Center	49	54	53	N/A	N/A	N/A

Source: [Reference 5.14]

The Village of Buchanan has a sound ordinance (Chapter 211-23 of the Village Zoning Code) that limits allowable sound levels from a facility by octave band levels and is applicable at the property line of the sound generating facility. The Village of Buchanan Sound Standard shown in Table 4.3.

Table 4.3: Buchanan Sound Standard

Octave Band Range (Hz)	Octave Band Center Frequency (Hz)	Sound Pressure Level (dB)
20 to 75	63	63
75 to 150	125	54
150 to 300	1250	49
300 to 600	500	44
600 to 1200	1000	40
1200 to 2400	2000	39
Above 2400	4000	34

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The combined octave band center frequencies equate to an overall level of 48 dB(A).

The hybrid cooling towers will be equipped with sound attenuators. The noise level is expected to be 30dB(A) at 2,750 feet, approximately 940 feet east of the intersection of Bleakley Avenue and Broadway. The sound level at the intersection of Bleakely Avenue and Broadway is calculated to be approximately 34 dB(A). This is less than the late night ambient noise levels at this location (Table 4.2). The sound level at the residence nearest the proposed location for the Unit 3 cooling tower is calculated to be approximately 31 dB(A). The Village of Buchanan Sound Standard of 48dB(A) is met at approximately 350 feet from each tower, well within Indian Point 2 and Indian Point 3 property boundaries. The cooling towers will be constructed in the side of a hill. The topography between the cooling towers and sensitive receptors will further attenuate the sound levels. Table 4.4 presents the calculated noise level at sensitive receptors including existing background noise and the operational noise of both cooling towers.

Table 4.4 Cumulative Sound Levels and Sensitive Receptors (dB(A))

Receptor	Cooling Tower Noise Level <sup>1</sup>	Existing Daytime L <sub>90</sub> <sup>2</sup>	Total Daytime Noise Level	Existing Late Night L <sub>90</sub> <sup>2</sup>	Total Late Night Noise Level
Saint Patrick's Church	29	41	41	42	42
16 <sup>th</sup> St & Broadway	30	38	39	40	40
Pheasant's Run	30	36	37	36	37
Buchanan Town Hall	28	44	44	38	38
Bleakley Ave. & Broadway	33	45	45	38	39
Elementary School	30	36	37	36	37
Nearest Residence	31	38	39	40	41
Centerville Park	30	36	37	36	37
China Pier	29	51	51	No Data	No Data

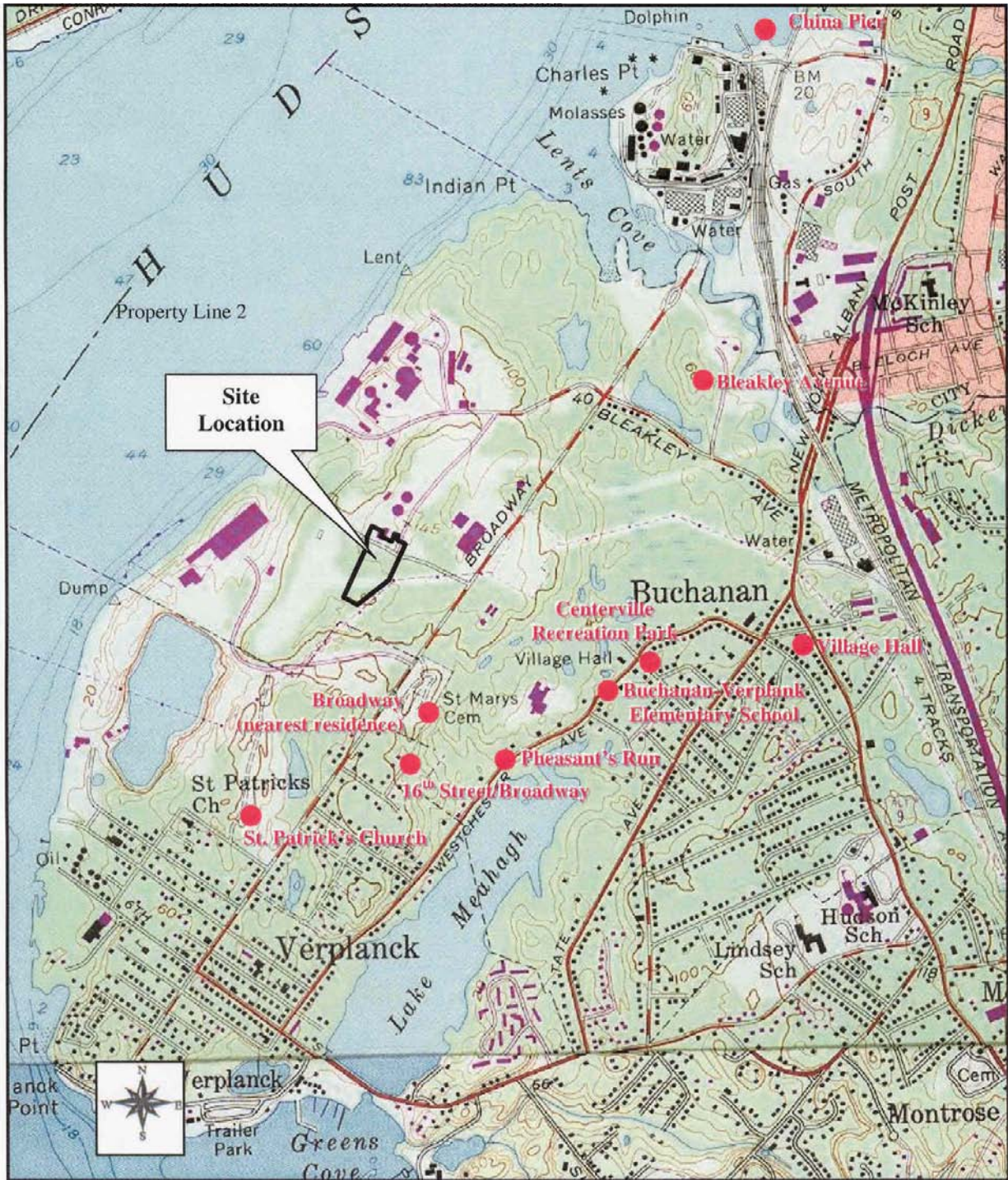
1 – Both towers operating continuously

2 – Source - [Reference 5.14]

This table reveals that both cooling towers operating continuously will cause in increase in noise levels at sensitive receptors of 1 dB(A) or less. This increase will probably not be noticed by the residents of the Village of Buchanan.

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Figure 4.1, Sound Receptor Locations [Reference 5.14]



#### 4.3 Site Aesthetics

When Indian Point Units 2 and 3 were constructed, the goal was to maintain a low physical profile for the generating Station vis-a-vis the Hudson River Valley through visual containment of Station structures within the confines of the surrounding forest-covered high ground [Reference 5.2]. Construction of the towers will require permanent modification of the terrain along the shore of the Hudson River.

The cooling towers will be located approximately 200 to 300 feet from the bank of the Hudson River at an elevation of about 30 feet mean sea level. The towers will be the largest structures on the Indian Point 2 and Indian Point 3 site. Each tower will be approximately 165 feet tall, about the height of a 14 story building, setting at an elevation of 30 feet msl, for a total height of 195 feet. Each tower will be approximately 525 feet in diameter. By comparison, the reactor containment structures are approximately 160 feet in diameter and 250 feet tall.

The cooling towers will have a substantial aesthetic impact [Attachment 2, page 2, Rendering]. An area approximately 700 feet in diameter will be excavated for each tower. In addition, approximately 1000 feet of river bank will be deforested to allow excavation for the 4 large diameter water pipes (2, 120" diameter supply pipes and 2, 144" diameter pipes to each condenser) required for each tower. Views from the Hudson River, scenic overlooks on area highways and from Palisades Interstate State Park on the western shore will be impacted. The Station is an industrial facility already visible from these vantage points, however, the addition of the two towers will make the entire facility more visible.

The clearcutting of the forest required for construction of the towers and to allow maximum airflow to the towers will remove a visual buffer from vantage points both up and down river. Because of this, as many trees between the construction sites and the river will be left as is possible. In addition, upon completion of construction, trees will be planted between the cooling towers and the River bank to reestablish a visual buffer and help attenuate noise from the operation of the towers.

The excavation for the cooling towers will cut into the side of the hills to the immediate east of the Station. These tree covered hills lie between the Station and the Villages of Buchanan and Verplanck and rise to an elevation of 130 to 145 feet, which will shield most of the tower from view, however many of the residents may still be able to see the tops of the towers above the tree tops. Because of the nature of hybrid cooling towers, no plume will be visible during the daylight hours. However, at night the towers will be run in wet mode, resulting in a plume of water vapor that may obscure the night sky for some residents.

#### 4.4 Construction Activities

The Indian Point Station is situated on the Hudson River amid steep rolling hills ranging in elevation between 20 and 120 feet msl. Indian Point 2 and Indian Point 3 are located on the east bank of the Hudson River in the village of Buchanan. The predominant land use within a two-mile radius of the Station is residential, recreational, and commercial. The populated area of Buchanan flanks the site to the east. The Town of Verplanck lies about a half a mile to the south and the Town of Peekskill lies about 1 mile to the north.

### Site Clearing and Excavation

Construction of the hybrid tower will entail significant excavation at the Station (Attachment 6). The base of the tower will be constructed on bedrock, at an elevation of about 30 feet above mean sea level. This will entail the removal of approximately 2 million cubic yards of material, primarily rock. Approximately 40 acres of land not previously disturbed will be cleared for the two cooling towers and new access roads.

The information presented here is primarily based on a survey of the vegetation of the Station environs [Reference 5.10]. The area immediately surrounding the Station is characterized by species of Eastern Deciduous Hardwood, regionally quite thick with a dense canopy. The forest has attained the codominant climax stand characteristic of a mature Eastern Hardwood forest (codominant species are defined as species of plants that, in combination, give the forest its characteristic appearance or physiognomy and may control its structure). In the intervening 30 years, the forests immediately surrounding the Station have not been cut, and remain a climax forest.

The dominant and codominant trees reported in this area were eastern hemlock (*Tsuga canadensis*, also known as Canadian hemlock), red oak (*Quercus rubra*), white oak (*Quercus alba*), chestnut oak (*Quercus prinus*), and shagbark hickory (*Carya ovata*), among others. The dominant and codominant trees were reported to range in height from 55 to 65 feet with diameter at breast height of 18 to 36 inches [Reference 5.10]. With 30 additional years of growth, many of these trees are larger now, though there is no recent quantitative information. The understory relationships in the Eastern Deciduous Hardwood forests are a ground canopy of witch-hazel (*Hamamelis virginiana*), flowering dogwood (*Cornus alternifolia*) and hickories, and a secondary canopy of eastern hemlock and witch-hazel. The forest floor is composed of up to a 2-inch layer of organic matter, mostly decaying leaves, and varying amounts of shrubs and herbs such as witch-hazel, Indian pipes, and Virginia creeper.

The impact of clear cutting this 40 acres is not easily definable. The obvious impacts include destruction of habitat for mammals that normally inhabit eastern hardwood forests, including raccoon, squirrels, opossum, and white tail deer. There is sufficient forest surrounding these areas to be cleared that forest fragmentation is not of concern. However, a large portion of the area surrounding the Station has been developed and the amount of undisturbed eastern deciduous hardwood forest in the vicinity is decreasing.

Clear cutting of the forest and subsequent excavation of the sites for the two cooling towers will alter the flow pattern of runoff from precipitation events. The volume of runoff potentially reaching the Hudson River will likely increase and the silt load of the runoff will increase because of the lack of trees and vegetation to hold the soil and slow the transport of water. Standard techniques of control of runoff will be implemented, such as silt fences and grading to control the flow of runoff during construction. Because the construction sites are so close to the river, extra protective measures to prevent runoff carrying excess silt and contaminants such as gas and oil, will be necessary. Temporary sediment retention basins may have to be constructed to prevent the increased silt load of the runoff from reaching the river. Truck and equipment washing areas will be equipped with impermeable basins to intercept petroleum contaminants. Dust from the construction site will be controlled by water sprays or, if necessary, other chemical dust suppression agents. All storage tanks containing gasoline, diesel fuel, or oils will have secondary containment to intercept spillage or leaks.

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Disposal of 2 million cubic yards of material is problematic. To transport the material to an acceptable disposal site by truck, assuming 6 cubic yards per load, would entail over 300,000 round trips. The excavation is expected to take 30 months to complete. This scenario would result in unacceptable impacts due to noise and traffic volume to the Village of Buchanan and the surrounding communities. The alternative disposal scenario would be to transport the material by barge to a suitable disposal site.

Construction Noise

Clearing, pile driving, and excavation of the site for the cooling towers will generate the most noise during the 5 year construction period. Excavation is expected to take 30 months and will entail blasting. An evaluation of construction noise was done for the Indian Point Peaking Facility (Figure 4.1) and, again, the excavation and grading of the site generated the most noise [Reference 5.14]. The results, depicted in Table 4.5, show that the calculated average construction sound levels were projected to be very close to the existing daytime sound levels at all sensitive receptor locations.

Work Force

Construction of the cooling towers will require a average work force of 300 and will take an estimated 62 months. During the outage phase of the effort, the work force will peak at 600. It is anticipated that the majority of the workforce will be temporary. Only a small percentage will look for permanent residence in the area. For comparison purposes, a work force of approximately 600 is on-site during a routine refueling outage. A fluctuating work force in the Buchanan/Verplanck area is normal and the additional workers for the cooling tower construction should not cause more severe problems than typically encountered during a refueling outage. Traffic in the area is heavy and the additional workers may cause increased traffic delays, particularly along the major routes; i.e., State Routes 9 and 9A.

Table 4.5: Comparison of Calculated Average Daytime Construction Phase Sound Levels For The Indian Point Peaking Facility to Existing Daytime  $L_{eq}$  Sound Levels At Residential Receptors (dBA)

Receptor (See Figure 4.4-1)	Initial Grading and Excavation		Concrete Pouring		Building Assembly		Siding and Machinery Installation		Exterior Finish and Cleanup	
	ACN	$L_{eq}$	ACN	$L_{eq}$	ACN	$L_{eq}$	ACN	$L_{eq}$	ACN	$L_{eq}$
Saint Patrick's Church	49 / 48		45 / 48		44 / 48		44 / 48		47 / 48	
16 <sup>th</sup> Street/Broadway	49 / 50		44 / 50		43 / 50		44 / 50		45 / 50	
Pheasant's Run	38 / 45		33 / 45		33 / 45		33 / 45		34 / 45	
Buchanan Town Hall	42 / 55		37 / 55		37 / 55		37 / 55		38 / 55	
Bleakley Avenue/Broadway	38 / 58		34 / 58		33 / 58		33 / 58		35 / 58	
China Pier	38 / 54		33 / 54		32 / 54		32 / 54		34 / 54	
School	48 / 45		43 / 45		42 / 45		42 / 45		46 / 45	
Nearest Residence	53 / 50		48 / 50		47 / 50		48 / 50		49 / 50	

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	Initial Grading and Excavation	Concrete Pouring	Building Assembly	Siding and Machinery Installation	Exterior Finish and Cleanup
(Broadway)					
Centerville Recreational Park	46 / 45	41 / 45	40 / 45	40 / 45	41 / 45

ACN = Average Construction Sound Level  
 L<sub>eq</sub> = Measured Daytime L<sub>eq</sub> Sound Level

The proposed sites for the cooling towers are a greater distance from sensitive receptors than the proposed location for the peaking facility (except for the Bleakley Avenue location, see Figure 4.1), so these results are directly applicable to the construction of the cooling towers.

#### 4.5 Reduced Intake Flow

The overall objective of converting Unit 2 and Unit 3 from once-through condenser cooling to closed-loop condenser cooling is a reduction of River intake flow. Although the qualification and quantification of environmental benefits from the associated reduction in entrainment and impingement of aquatic fish and shellfish is not within the scope of this Report, the quantification of the reduction in River intake flow is a significant assessment.

Current River intake flow for ENIP 2/3 Station is as follows [References 5.8 and 5.9]:

Unit 2 Circulating Water <small>Maximum*</small>	840,000 gpm
Unit 2 Service Water <small>Includes some U1 flow</small>	31,000 gpm
Unit 3 Circulating Water <small>Maximum*</small>	840,000 gpm
Unit 3 Service Water	20,000 gpm
<b>Total Intake Flow <small>Once Through, Maximum*</small></b>	<b>1,731,000 gpm</b>

\*Flow at maximum pump performance during summer River temperature conditions.

Current plant design utilizes significantly reduced River intake flow in the winter, when cold water temperatures support reduced flow operation. At minimum flow conditions, Unit 2 circulating water flow is  $(6_{\text{pumps}}) \times 84,000 \text{ gpm} = 504,000 \text{ gpm}$ , and Unit 3 circulating water flow is  $(6_{\text{pumps}}) \times 69,167 \text{ gpm} = 415,000 \text{ gpm}$  <sup>Note 1</sup>, for a combined flow of:

<b>Total Intake Flow <small>Once Through, Minimum</small></b>	<b>919,000 gpm</b>
---------------------------------------------------------------	--------------------

Note 1:  $(6_{\text{pumps}}) \times 54,000 \text{ gpm} = 324,000 \text{ gpm}$  is the theoretical Unit 3 minimum flow, and is the target minimum flow when it will support plant operation. A minimum flow of 415,000 gpm is always attainable in winter, hence was used for conservatism.

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River intake flow for the Station following conversion to closed-loop cooling is as follows:

Typical summer conditions,

Unit 2 Circulating Water Makeup <small>Average Summer</small>	16,000 gpm
Unit 2 Service Water <small>Includes some U1 flow</small>	31,000 gpm
Unit 3 Circulating Water Makeup <small>Average Summer</small>	16,000 gpm
Unit 3 Service Water	20,000 gpm
Total Intake Flow <small>Closed Loop</small>	83,000 gpm
Total Intake Flow <small>Once Through, Maximum</small>	1,731,000 gpm
Reduction In River Intake Flow <small>Maximum</small> 95.2%	

Typical winter conditions,

Unit 2 Circulating Water Makeup <small>Average Winter</small>	7,800 gpm
Unit 2 Service Water <small>Includes some U1 flow</small>	31,000 gpm
Unit 3 Circulating Water Makeup <small>Average Winter</small>	7,800 gpm
Unit 3 Service Water	20,000 gpm
Total Intake Flow <small>Closed Loop</small>	66,600 gpm
Total Intake Flow <small>Once Through, Minimum</small>	919,000 gpm
Reduction In River Intake Flow <small>Minimum</small> 92.8%	

Although the summer and winter makeup rates utilized above are both based on average values, since the makeup flow will vary (be controlled) based on River water chemistry, the maximum variance on the percentage reduction in River intake flow is less than +/- 1%.

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5.0 References

- 5.1 *Economic and Environmental Review of Closed Cooling Water Systems for the Hudson River Power Plants*, Power Tech Associates, Paramus, New Jersey, November 1999.
- 5.2 *Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 2*, Consolidated Edison Company of New York, Inc., Volume No. 1, December 1, 1974.
- 5.3 *Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 3*, Consolidated Edison Company of New York, Inc., Volume No. 1, January 1976.
- 5.4 *Cooling Tower Fundamentals*, Marley Cooling Tower Company, Second Edition, 1998.
- 5.5 *Circular Hybrid Cooling Towers*, Cooling Technology Institute, Paper No: TP00-11, Ph.D. Andreas Streng, February 2000.
- 5.6 *Minimizing the Power Consumption of Hybrid Cooling Towers by Process-Controlled Mode of Operation*, Paper of Oral Presentation, 9<sup>th</sup> Cooling Tower and Spraying Pond Symposium, International Association for Hydraulic Research, Walter Tesche, September, 1994.
- 5.7 *ASHRAE Fundamentals*, American Society of Heating, Refrigerating and Air Conditioning Engineers, 2001 edition.
- 5.8 *Indian Point Station, Unit No. 2, System Description No.. 23, Circulating Water System*, Revision 3, April 1985.
- 5.9 *Indian Point. 3, System Description 23.0, Circulating Water System*, Revision 2, December 27, 2001.
- 5.10 *Vegetation Survey of the Indian Point Environs*, Prepared for Consolidated Edison Company, Dames & Moore, March 1973.
- 5.11 *Engineering Manual 1110-2-3105, Mechanical and Electrical Design of Pumping Stations*, U. S. Army Corps of Engineers, Changes 1 and 2, Nov. 30, 1999.
- 5.12 *Effects of Aerosol Drift Produced by the Cooling Tower at the Indian Point Generating Station on Native and Cultivated Flora in the Area*, Boyce Thompson Institute, Yonkers, New York, 1974.
- 5.13 *Umatilla Generation Project, Final Environmental Impact Statement*, Bonneville Power Administration, DOE/EIS-0324.
- 5.14 *Indian Point Peaking Facility, Sound*, TRC Environmental, Draft Report 2003, with background noise survey data from 2001 and 2002.

Economic and Environmental Impacts Associated with  
Conversion of Indian Point Units 2 and 3 To A Closed- Loop  
Condenser Cooling Water Configuration

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6.0 Attachments

- 6.1 Attachment 1 – Major Components; Vendor Data and Reference Information (pages 1 to 30)
- 6.2 Attachment 2 – Post-Modification Site Renderings and Conceptual Drawings (pages 1 to 7)
- 6.3 Attachment 3 – PEPSE Model Results / Plant Performance Versus Condenser Inlet Water Temperature (pages 1 to 19)
- 6.4 Attachment 4 – Regulatory Issues (pages 1 to 3)
- 6.5 Attachment 5 – Plume Model / Salt Deposition Analysis (pages 1 to 23)
- 6.6 Attachment 6 – Capital Costs Assessment (w/ Appendix 6A, Precision Blasting and Rock Removal Report, and Appendix 6B, Cooling System Conversion Schedule) (pages 1 to 18)
- 6.7 Attachment 7 – Electrical Distribution Model Output Reports (pages 1 to 14)