EXHIBIT E

Vogtle Units 3 and 4: Feasible and Cost-Effective Water Conservation Measures

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I. Executive Summary

Vogtle Units 3 and 4, as currently designed, will utilize hyperbolic natural draft wet cooling towers. The Georgia Environmental Protection Division (EPD) has issued draft water permit for Vogtle Units 3 and 4 that allows a maximum water withdrawal rate of 74 million gallons per day (mgd) from the Savannah River, and contemplates a discharge of up to 8.6 mgd of saline cooling tower blowdown to the river. Plant Vogtle is required to implement a water conservation plan to minimize water withdrawals from the Savannah River. Feasible and cost-effective technologies that would substantially reduce Unit 3 and 4 water withdrawals and cooling tower blowdown discharges are: 1) conversion of the wet-only cooling systems to indirect wet-dry cooling, and 2) addition of a zero liquid discharge (ZLD) treatment and recycling system to eliminate discharges to the Savannah River and reduce cooling system water withdrawals. The total installed capital cost of these water conservation measures would be on the order of $360 million. This cost is in the range of 2.0 percent of the projected $15.5 billion capital cost of Vogtle Units 3 and 4.

II. Background

Vogtle Units 3 and 4 are currently being built as wet cooling-only units using hyperbolic natural draft cooling towers. The draft Georgia EPD water withdrawal permit would allow Units 3 and 4 to withdraw up to 74 mgd of Savannah River water. The average expected withdrawal rate specified in the draft permit is 62 mgd. Presumably, Units 3 and 4 will also be permitted to discharge about 9 million gallons per day of brackish cooling tower blowdown back to the Savannah River.

Existing Vogtle Units 1 and 2 are permitted to withdraw a maximum of 127 mgd from the Savannah River.[1] The combined Vogtle Units 1-4 maximum withdrawal rate will be 201 mgd if the Unit 3 and 4 maximum withdrawal limit of 74 mgd is retained in the final permit.

Georgia has experienced severe droughts in recent years and is likely to experience severe droughts in the future. Several Georgia power plants have had their output curtailed due to drought or high water temperature conditions, including nuclear Plant Hatch. Drought-related curtailments can and do occur during times of peak power demand. For wet-cooled power plants in Georgia like Vogtle 3 and 4, drought represents a threat to plant reliability during summertime periods of peak demand.

[1] Georgia EPD, *Permit to Withdraw, Divert, or Impound Surface Water – Southern Nuclear Operating Company - Vogtle (Units 1 and 2)*, Permit Number 017-0191-05 (renewal), May 30, 2000. Maximum 24-hour withdrawal rate = 127 mgd, monthly average = 85.0 mgd.

Two feasible, cost-effective technologies are available to substantially reduce water usage by Vogtle Units 3 and 4: indirect wet-dry cooling and zero liquid discharge (ZLD) from the cooling system.

There is precedent for a U.S. nuclear plant being permitted to operate with a parallel wet-dry cooling system. The application for the Dominion Nuclear North Anna Unit 3 project (VA), a 1,300 MW boiling water reactor, includes a parallel wet-dry cooling system designed to reduce water consumption by 70 percent.[2] North Anna Unit 3 is about 30 percent larger in terms of size, and in terms of cooling system heat rejection need, than Units 3 or 4 at Plant Vogtle.

Large direct and indirect wet-dry cooling systems are in use in the U.S. and overseas. The 750 MW Comanche 3 (Colorado) is an operational coal plant that utilizes parallel wet-dry cooling in a direct dry cooling configuration.[3] The 860 MW Matra PS is an operational lignite-fired plant in Hungary that utilizes wet-dry cooling in an indirect dry cooling (Heller) configuration on two of its units.[4] This is the appropriate wet-dry retrofit technology for Units 3 and 4 at Plant Vogtle.

III. Indirect Wet-Dry Cooling

a. Description of Technology as Applied to Vogtle Units 3 and 4

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[2] Nuclear Regulatory Commission, *NUREG-1811: Final Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site - Volume I*, December 2006, p. 8-4. See: http://pbadupws.nrc.gov/docs/ML0634/ML063470330.pdf. "Section 8.2.2 Plant Cooling System: Unit 3 Wet Cooling System. Wet, mechanical and natural draft cooling towers transfer heat to the atmosphere through evaporation and conduction. Assuming all the heat transfer is through evaporation, a wet cooling design would consume more water than either the once-through design or the combination wet and dry cooling system proposed in the ER (Dominion 2006). The increased use of makeup water requirements for a wet cooling design would increase impingement and entrainment slightly over the proposed design.

The use of a wet cooling tower design versus the proposed combination wet and dry cooling system design for Unit 3 would increase water withdrawals from Lake Anna. The impact of the increased evaporative losses of a wet cooling tower design would be particularly noticeable during drought years. The results of water balance calculations suggest that the use of a wet cooling tower system for the 2001 through 2003 critical water period would have resulted in an additional 1.0 m (3.4 ft) drawdown of the lake in September 2002. In comparison, use of the proposed combination wet and dry cooling system would only have drawn the lake down by an additional 0.5 m (1.6 ft). The use of a wet cooling tower design would also prolong the duration of low-flow conditions downstream of the dam. The staff concludes that based on the expected smaller impact on the lake level and downstream flows, a combination wet and dry cooling system design for Unit 3 is preferable to a wet cooling tower design.

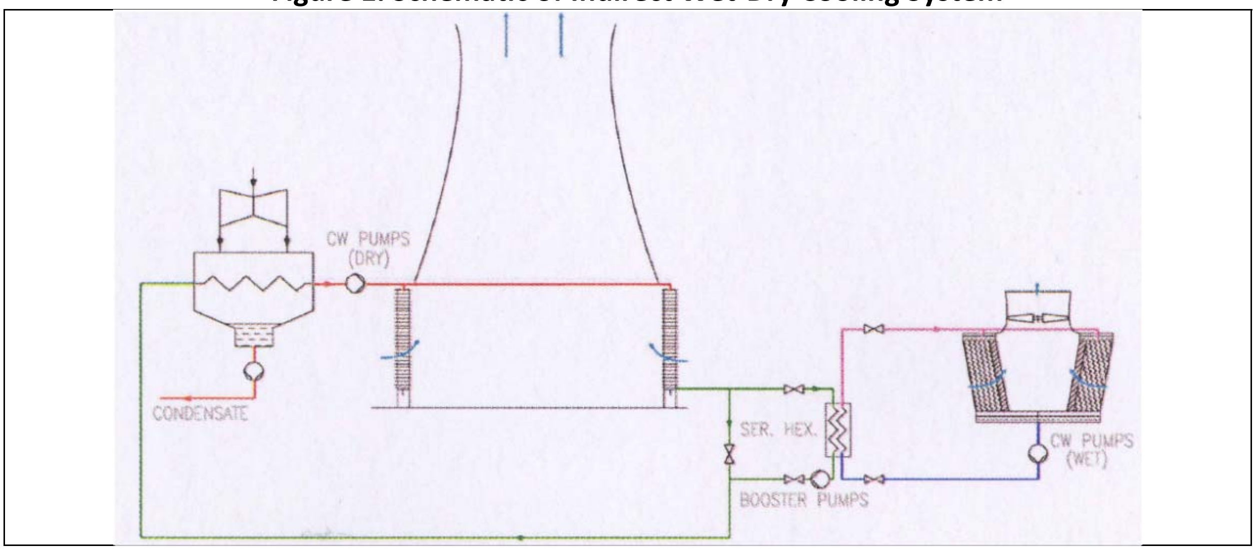
p. 8-5: The staff concludes that based on its analysis that Lake Anna could support Unit 3 using a combination wet and dry cooling system and given the environmental impact of increased use of resources needed by using a less efficient dry cooling system, a combination wet and dry cooling system is preferable to a dry cooling system for Unit 3."

[3] GEA Power Cooling, Inc., *Xcel Energy/ACC Users Meeting – Retrofit of an Air-Cooled Condenser (ACC) to an Existing Water-Cooled Condenser System*, PowerPoint presentation, September 28-29, 2010, pp. 14-17.

[4] GEA Heat Exchangers, *Feasible Dry and Dry/Wet Cooling Systems for Large Nuclear Plants*, PowerPoint presented at Nuclear Industry Conference Africa 2014, February 25-26, 2014, p. 39.

The indirect wet-dry cooling system consists of an air cooler, essentially a large radiator, located inside a hyperbolic natural draft cooling tower and a small wet cooling tower that work in combination to achieve the required cooling. An indirect wet-dry cooling is the best choice of retrofit air cooling retrofit options for Units 3 and 4. The indirect air cooler can use standard tube material and no modifications are required to the Unit 3 and 4 surface condensers. A schematic of the indirect wet-dry cooling system is shown in Figure 1.

Figure 1. Schematic of Indirect Wet-Dry Cooling System[5]



Vogtle 3 and 4 are relatively ideal candidates for an indirect wet-dry retrofit. The most costly component of the indirect wet-dry cooling system is the hyperbolic tower. The hyperbolic tower is common to the current Vogtle 3 and 4 wet cooling system and a retrofit indirect wet-dry system. The Vogtle Units 3 and 4 hyperbolic towers are currently under construction. In the most efficient version of an indirect wet-dry cooling system retrofit, the air-cooled heat exchangers would be located in the base of the under-construction hyperbolic tower(s) in place of the wet cooling plastic media that would otherwise be placed there.

Most of the necessary cooling would occur at the hyperbolic tower. A relatively small inline wet cooling tower would be added, on the order of 12 cells,[6] to provide the additional cooling necessary to achieve performance levels that are approximately equivalent to what Vogtle 3 and 4 will achieve with wet-only

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[5] GEA EGI Contracting/Engineering Company Ltd, *Investigation of Conversion of Wet to Dry/Wet Cooling System for (1,000 MW) Coal-Fired Power Plant USA*, September 16, 2013, p. 27.

[6] Progress Energy Florida, *Levy Nuclear Plant Units 1 and 2 – Part 3, NRC Environmental Report*, Figure 3.4-1 LNP CWS Cooling Tower Performance Curves, pp. 1-2. Progress Energy Florida proposed to use the same AP1000 reactor being constructed at Vogtle Units 3 and 4. The cooling system heat rejection requirement is 7,600 MMBtu/hr for the AP1000. Progress Energy Florida specified 44-cell back-to-back mechanical draft cooling towers for Levy Units 1 and 2, using cooling tower cells with L x W dimensions of 48 feet x 54 feet, to reject 7,600 MMBt/hr at a design wet bulb temperature of 83 degrees F. The number of cooling cells required to reject 30 percent of the 7,600 MMBtu/hr heat load at design conditions would be: 0.30 x 44 cells = ~13 cells. Assuming use of 12 wet tower cells in an indirect wet-dry cooling system retrofit at Vogtle Units 3 and 4, to achieve 70 percent air cooling and 30 percent wet cooling at design conditions, is reasonable based on the wet cooling tower specified for Levy Units 1 and 2.

cooling. A 12-cell mechanical draft cooling tower, with a design heat removal capability of approximately 2,200 MMBtu/hr, is shown in Figure 2. In the case of Vogtle Units 3 and 4, the wet cooling towers would be located in close proximity to the hyperbolic natural draft cooling towers. The hyperbolic natural draft cooling towers under construction are shown in Figure 3, along with possible locations for two retrofit mechanical draft wet cooling towers.

Figure 2. 12-Cell Back-to-Back Mechanical Draft Cooling Tower[7]

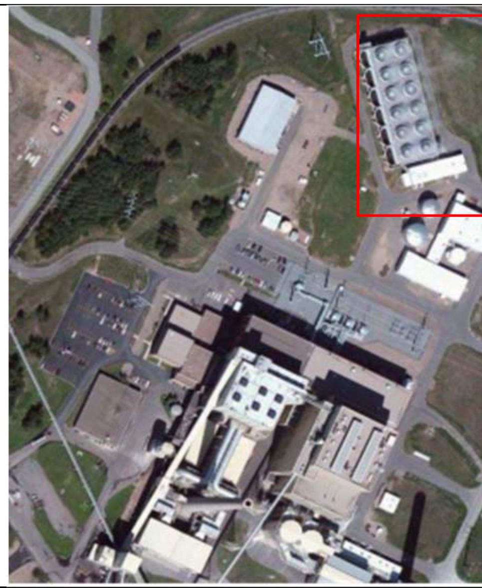

Figure 3. Hyperbolic Natural Draft Cooling Towers Under Construction at Vogtle Units 3 and 4 and Possible Locations for 12-Cell Back-to-Back Wet Cooling Towers[8]

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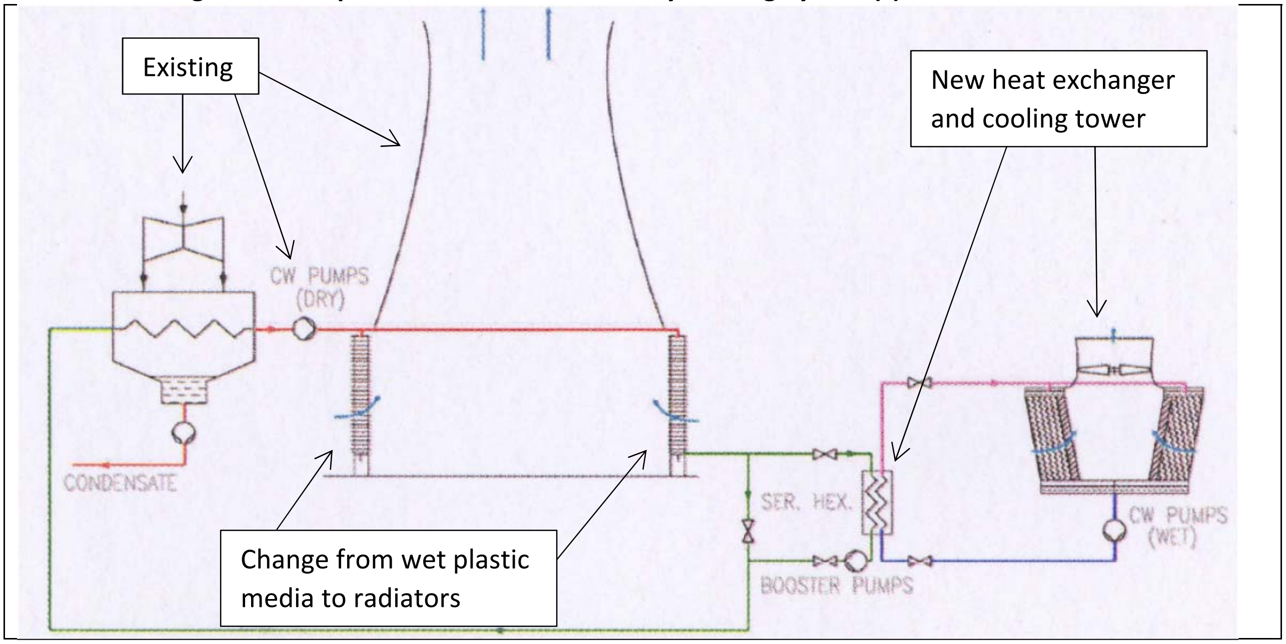
[7] Google Earth photo, Wisconsin Public Service Company, 515 MW (net) Weston Unit 4.
[8] Google Earth photo, Unit 3 and 4 cooling towers under construction, tags by B. Powers, Powers Engineering.

Figure 4 shows what components of a retrofit indirect wet-dry cooling system for use at Units 3 and 4 are part of the original Unit 3 and 4 cooling system design and what components would be additional.

Figure 4. Components of Indirect Wet-Dry Cooling System(s) on Units 3 and 4[9]



b. Estimated Cost of Indirect Cooling tower Retrofit at Vogtle Units 3 and 4

The main hardware costs necessary to convert the under construction wet cooling systems at Vogtle Units 3 and 4, which will utilize hyperbolic natural draft cooling towers, to indirect wet-dry cooling systems include: wet cooling tower, heat exchanger, and two sets of booster pumps (to overcome the hydraulic resistance of the cooling tower and heat exchanger).

GEA EGI Contracting/Engineering Company, the licensee for indirect wet-dry cooling technology in the U.S., has estimated an installed capital cost of approximately $160 million per 1,000 MW of coal plant capacity for indirect wet-dry cooling, in 2013 dollars.[10] This cost assumes that the existing inline mechanical draft cooling towers at the coal plant are incorporated into the retrofit indirect wet-dry cooling system.

Electric Power Research Institute ("EPRI") has identified the unit cost for an inline wet cooling tower retrofit as $263/gpm.[11] The estimated circulating cooling water flowrate for a 12-cell mechanical draft cooling tower for use in indirect wet-dry cooling system(s) on Vogtle Units 3

[9] GEA EGI Contracting/Engineering Company Ltd, *Investigation of Conversion of Wet to Dry/Wet Cooling System for (1,000 MW) Coal-Fired Power Plant USA*, September 16, 2013, p. 27. Tags added by B. Powers, Powers Engineering.
[10] Ibid, p. 45.
[11] EPA, *Draft Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Rule*, March 27, 2011, Exhibit 8-6, p. 8-18.

and 4 would be 180,000 gpm.[12] The cost estimated by EPRI for each 12-cell cooling tower is: \$263/gpm x 180,000 gpm = \$47 million.

Based on this EPRI installed cost estimate for the 12-cell wet cooling tower and the GEA cost estimate for an indirect wet-dry cooling system retrofit at a 1,000 MW coal plant, the installed capital cost of the radiators installed at the base of the hyperbolic natural draft cooling tower, the water-to-water heat exchanger, and the two sets of booster pumps/pump pits would be on the order of \$110 million.[13]

At a cost of \$160 million per unit, indirect wet-dry cooling retrofits for both Units 3 and 4 would be in the range of \$320 million. This represents about two percent of the current estimated \$15.5 billion installed capital cost of Units 3 and 4.[14]

IV. Zero Liquid Discharge Technology for Vogtle Units 3 and 4 Cooling Systems

Zero liquid discharge (ZLD) technology can be used to treat cooling system blowdown discharges from Units 3 and 4 cooling towers whether or not indirect wet-dry cooling is utilized. ZLD uses reverse osmosis and crystallizers to recycle cooling tower blowdown and eliminate the blowdown wastewater stream.[15] The recycling of cooling tower blowdown would reduce the amount of Unit 3 and 4 cooling system water withdrawals from the Savannah River.

The draft permit and supporting documentation contemplate that Units 3 and 4 will discharge up to approximately 9 mgd of cooling tower blowdown to the Savannah River. The installed capital cost of a ZLD treatment system capable of treating up to 10 mgd of cooling tower blowdown is approximately \$32 to 42 million, depending on the type of ZLD system selected.[16]

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[12] 180,000 gpm is 30 percent of the Levy Unit 1 and 2 wet cooling tower(s) design circulating water flowrate of 600,000 gpm.

[13] Total installed cost of retrofit indirect wet-dry cooling system = \$160 million. \$47 million of this cost is mechanical draft cooling tower. Balance of system costs, including radiators at base of hyperbolic natural draft cooling tower, water-to-water heat exchanger, and two sets of booster pumps/pump pits, would be on the order of: \$160 million - \$47 million = ~\$110 million.

[14] Georgia Power, *Vogtle Units 3 and 4 8th Semi-Annual Construction Monitoring Report*, Docket No. 29849, February 2013. See: http://www.georgiapower.com/docs/about-energy/8th-VCM-Report.pdf. Pursuant to a settlement agreement (see: http://www.psc.state.ga.us/GetNewsRecordAttachment.aspx?ID=267), the Georgia PSC has postponed Georgia Power Company's certified cost increase request for Vogtle Units 3 and 4 until Unit 3 is completed.

[15] Global Water Intelligence, *From zero to hero – the rise of ZLD*, December 2009. See: http://www.globalwaterintel.com/archive/10/12/market-insight/from-zero-to-hero-the-rise-of-zld.html.

[16] R. Al-Samadi, PhD P.E. – Advanced Water Solutions, ARROW™ Enhanced Product Water Recovey Cost Benefits (spreadsheet), 10 mgd ZLD system capital cost range = \$32 to 42 million, net annual cost range = \$8.5 to 13.7 million, May 24, 2012. See: http://www.advancedwatersolutions.com/uploaded/link/Cost%20Benefits%20of%20ARROW%20May%2024%202012.pdf, and http://www.advancedwatersolutions.com/.

V. Conclusions

Indirect wet-dry cooling system retrofits are feasible and cost-effective for Vogtle Units 3 and 4. These retrofits would reduce cooling system water withdrawals by at least 70 percent. ZLD technology is cost-reasonable and would eliminate cooling tower blowdown discharges to the Savannah River from the Units 3 and 4 cooling systems. Use of ZLD would also reduce water withdrawals from the Savannah River proportionate to the amount of water recycled onsite by use of the ZLD system. The capital cost of indirect wet-dry cooling system retrofits ($320 million) and a ZLD system ($32 to 42 million) for Units 3 and 4 would be on the order of 2.0 to 2.5 percent of the projected $15 billion capital cost of Units 3 and 4.

ATTACHMENT: C.V., Bill Powers, P.E.