

1. INTRODUCTION AND GENERAL DESCRIPTION

1.1 Introduction

Exelon Generation Company, LLC (EGC or the applicant), filed an application with the U.S. Nuclear Regulatory Commission (NRC), docketed on October 27, 2003, for an early site permit (ESP) for a site the applicant designated as the EGC ESP site. EGC requested an ESP with a permit duration of 20 years pursuant to Subpart A, "Early Site Permits," of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants." The proposed site is located approximately 6 miles east of the city of Clinton in east-central Illinois.

Exelon states that the purpose of its application for an ESP is to set aside the proposed site for future energy generation and sale on the wholesale energy market. This site would be reserved for a nuclear facility to be operated as a merchant generator plant. In addition, a component of the site redress plan supports a (limited work) authorization for approval of construction activities in accordance with 10 CFR 50.10(e)(1) and 10 CFR 52.17(c).

The staff has completed its review in the areas of the site seismology, geology, meteorology, and hydrology, as well as of hazards to a nuclear power plant that could result from man-made facilities and activities on or in the vicinity of the site. The staff also assessed the risks of potential accidents that could occur as a result of the operation of a nuclear plant(s) at the site and evaluated whether the site would support adequate physical security measures for a nuclear power plant(s). The staff evaluated whether the applicant's quality assurance measures were equivalent in substance to the measures discussed in Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." The NRC found that the applicant's measures provide reasonable assurance that the ESP information that could be used in the design and/or construction of structures, systems, and components (SSCs) important to safety would support satisfactory performance of such SSCs once they were in service. The staff also evaluated the adequacy of the applicant's program for compliance with 10 CFR Part 21, "Reporting of Defects and Noncompliance." Finally, the staff reviewed the proposed major features of the emergency plan that EGC would implement if new reactor unit(s) is eventually constructed at the ESP site. The NRC will review the complete and integrated emergency plan in a separate licensing action.

The EGC ESP application includes the site safety analysis report (SSAR), which describes the safety assessment of the site, as required by 10 CFR 52.17, "Contents of Applications." The public may inspect the ESP application via the Agencywide Documents Access and Management System (ADAMS) under ADAMS Accession No. ML032721596.⁴ EGC

⁴ADAMS (Agencywide Documents Access and Management System) is the NRC's information system. It provides access to all image and text documents that the NRC has made public since November 1, 1999, as well as bibliographic records (some with abstracts and full text) that the NRC made public before November 1999. Documents available to the public may be accessed via the Internet at <http://www.nrc.gov/reading-rm/adams/web-based.html>. Documents may also be viewed by visiting the NRC's Public Document Room at One White Flint North, 11555 Rockville Pike, Rockville, Maryland. Telephone assistance for using Web-based ADAMS is available at (800) 397-4209 between 8:30 a.m. and 4:15 p.m., eastern standard time, Monday through Friday, except Federal holidays. The staff is also making this SER available on the NRC's new

subsequently revised its application to address requests from the NRC staff for additional information. The applicant submitted the most recent version, SSAR Revision 4 (application), to the Commission on April 14, 2006 (ADAMS Accession No. ML061100260).

Appendix B to this report provides a chronological list of the licensing correspondence between the applicant and the Commission regarding the review of the EGC ESP application under Project No. 718 and Docket No. 52-007. The application and other pertinent information and materials are available for public inspection at the NRC's Public Document Room at One White Flint North, 11555 Rockville Pike, Rockville, Maryland. The application and this safety evaluation report (SER) are also available at the Vespasian Warner Public Library, 310 North Quincy Street, Clinton, Illinois, as well as on the NRC's new reactor licensing public Web site at <http://www.nrc.gov/reactors/new-licensing/esp/clinton.html>. This SER is also available in ADAMS under Accession No. ML060470383.

This SER summarizes the results of the staff's technical evaluation of the suitability of the proposed EGC ESP site for construction and operation of a nuclear power plant(s) within the plant parameter envelope (PPE) that EGC specified in its application. This SER delineates the scope of the technical matters that the staff considered in evaluating the suitability of the site. NRC Review Standard (RS)-002, "Processing Applications for Early Site Permits," Attachment 2, provides additional details on the scope and bases of the staff's review of the radiological safety and emergency planning aspects of a proposed nuclear power plant site. RS-002, Attachment 2, contains regulatory guidance based on NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (hereafter referred to as the SRP). The SRP reflects the staff's many years of experience in establishing and promulgating guidance to enhance the safety of nuclear facilities and in evaluating safety assessments. In addition, this SER documents the resolution of the open and confirmatory items identified in the draft safety evaluation report (DSER) for the EGC ESP, issued on February 10, 2005.

In the DSER, the NRC identified Confirmatory Item 1.1-1 to verify that EGC's future revision of its ESP application is consistent with the information provided in its requests for additional information (RAIs) responses. Throughout the course of the review, the staff requested that the applicant submit additional information to clarify the description of the EGC ESP site. This report discusses some of the applicant's responses to these RAIs. The staff reviewed the revisions of the EGC ESP application, up to and including Revision 2 of the SSAR, and determined that the ESP application is consistent with the information provided in its RAI responses. Therefore, the staff considers DSER Confirmatory Item 1.1-1 to be resolved.

At the time the DSER was issued, the staff had not completed its review in the areas of seismology and geology. In the DSER, the staff identified Confirmatory Item 1.1-2 for issuance of a supplemental DSER at a later date to summarize the results of its technical evaluation of the suitability of the proposed EGC ESP site with respect to the site's seismology and geology. The supplemental DSER was issued on August 26, 2005 (ADAMS Accession No. ML052310459). Therefore, the staff considers Confirmatory Item 1.1-2 to be resolved.

reactor licensing public Web site at <http://www.nrc.gov/reactors/new-licensing/esp/north-anna.html>.

The applicant also filed an environmental report for the EGC ESP site in which it evaluated those matters relating to the environmental impact assessment that can be reasonably reviewed at this time. The staff discussed the results of its evaluation of the environmental report for the EGC ESP site in a draft environmental impact statement (DEIS) issued on March 2, 2005 (ADAMS Accession No. ML050610364). The applicant also provided a site redress plan, in accordance with 10 CFR 52.17(c), for performing the site preparation and limited construction activities allowed by 10 CFR 52.25(a) (i.e., the activities listed in 10 CFR 50.10(e)(1)). The DEIS also includes the results of the staff's evaluation of that plan.

As described above, the applicant supplemented the information in the SSAR by providing revisions to the document. The staff reviewed these revisions to determine their impact on the conclusions in this SER. On February 17, 2006, the NRC issued its SER for the EGC ESP site and made it publically available. EGC identified that the site characteristic for the probable maximum flood (PMF) elevation proposed by the staff in the SER was somewhat higher than that calculated by EGC in its ESP application. By letters dated March 24, 2006, and April 12, 2005, EGC requested that the staff review its revised PMF analysis and adopt its corresponding PMF level as the site characteristic. By letter dated April 14, 2006, EGC provided Revision 4 to the EGC ESP application, which documented EGC's revised PMF analysis. The changes reflected in Revision 4 of the application included revisions to the tables, figures and text in Section 2.4 to reflect EGC's revised PMF analysis. This included changes to the maximum rainfall rate, the maximum hydrostatic PMF water surface elevation, the coincident wind wave activity, and the maximum storm surge. EGC presented PMF calculations using two different synthetic unit hydrograph methods (the Synder method and the Soil Conservation Service method) with two different conceptual watershed layouts (a two-basin plus lake model and a seven-basin plus lake model). The staff completed its review of the most recent version, Revision 4, of the SSAR, as documented throughout this report and, for the reasons set forth herein, finds it to be acceptable. The changes to the application in Revision 4 resulted in minor modifications to the staff's SER issued February 17, 2006, including the following changes: Section 2.4 of this SER was modified to incorporate EGC's revised PMF analysis and the staff's independent confirmatory analysis; Appendix A of this SER was modified to reflect the new site characteristics related to the revised PMF elevation; Appendix B of this SER was modified to include Revision 4 of the application; and Appendix C of this SER was modified to include reference documents used by the staff in its review of EGC's revised PMF elevation. The changes to this SER also include modifications to Section 2.4 to better describe the technical information in the application regarding EGC's ice thickness calculations. The scope of all other changes to the SER issued on February 17, 2006, resulting from Revision 4, are limited to corrections of factual inaccuracies; these changes did not impact the staff's conclusions.

Appendix A to this SER contains the list of site characteristics, permit conditions, combined license (COL) action items, and the bounding parameters that the staff recommends that the Commission include in any ESP that might be issued for the proposed site. Appendix B to this SER is a chronology of the principal actions and correspondence related to the staff's review of the ESP application for the EGC ESP site. Appendix C lists the references for this SER, Appendix D lists the principal contributors to this report, and Appendix E includes a copy of the report by the ACRS.

1.2 General Site Description

The EGC ESP facility will be co-located on the property of the existing Clinton Power Station (CPS) facility. The CPS site, with its associated 4895-acre, man-made cooling reservoir (Clinton Lake), is an irregular U-shaped site in DeWitt County in east-central Illinois about 6 miles east of the city of Clinton. The site is located between the cities of Bloomington and Decatur to the north and south, respectively, and Lincoln and Champaign-Urbana to the west and east, respectively. The total area encompassed by the ESP site boundary is about 14,180 acres. The site includes an area that extends approximately 14 miles along Salt Creek and 8 miles along the North Fork of Salt Creek, and is about 3 miles northeast of the confluence of Salt Creek and the North Fork of Salt Creek. Figure 1.2-1 in the site safety analysis report (SSAR) depicts the site location; Section 2.1 of this SER discusses the site location in more detail.

With regard to the existing development of the site, CPS Unit 1 is a Boiling Water Reactor 6 (BWR-6), with a rated core thermal power level of 3473 megawatts (thermal) (MWt) and a gross electrical output of 1138.5 megawatts (electric) (MWe). AmerGen Energy Company, LLC (AmerGen), is the licensed owner and operator of the CPS. AmerGen is a wholly owned subsidiary of EGC. EGC is a wholly owned subsidiary of Exelon Ventures Company, LLC, which in turn is a wholly-owned subsidiary of Exelon Corporation. SSAR Figure 1.2-2 provides an aerial view of the EGC ESP site showing the existing development.

With regard to the proposed development of the site, AmerGen owns the real estate on which the EGC ESP facility will sit, including the exclusion area, with the exception of a right-of-way for the township road that traverses the exclusion area. The applicant entered an access and indemnity agreement with AmerGen to obtain the rights to conduct preliminary studies and perform other activities necessary to support the EGC ESP application process. The applicant has stated that before any construction, it plans to enter into an agreement with AmerGen, that will grant EGC an exclusive and irrevocable option to purchase, enter a long-term lease, and/or procure other legal right in the land required for the EGC ESP facility. The staff proposes to include a permit condition to govern exclusion area control on any ESP that may be issued in connection with this application. Section 2.1.2 of this report discusses this issue in detail.

The applicant has not selected a specific reactor type for the EGC ESP site. However, to support its ESP application, Exelon used available information from a range of possible facilities to characterize the proposed development. The EGC ESP facility would be located approximately 700 feet south of the current CPS facility on the existing CPS property. SSAR Figure 1.2-3 shows the location of the EGC ESP site footprint and the distance by sector from the outside boundary of the footprint to the CPS property line. Depending on the reactor type selected, the EGC ESP facility could have a total core thermal power rating between approximately 2400 and 6800 MWt. The EGC ESP facility would consist of a single reactor or multiple reactors (or modules) of the same reactor type. SSAR Section 1.3 provides an overview of the reactor designs considered in developing the information necessary to support Exelon's ESP application. The EGC ESP facility could be any of the reactor designs described in the application or a new design that falls within the range of the information developed to characterize the facility (i.e., the plant parameter envelope (PPE)).

According to the applicant, the EGC ESP facility would be constructed as a large industrial facility similar in general appearance to the existing CPS facility. However, unlike the existing plant, which uses the Clinton Lake for normal cooling processes, the EGC ESP facility would use cooling towers. Clinton Lake would be used as the source of makeup water for the EGC ESP facility cooling water systems.

A new intake structure, located on Clinton Lake adjacent to the existing CPS Unit 1 intake structure, would provide raw water for cooling tower makeup and other plant services. Cooling tower blowdown and other plant discharges would use the existing CPS Unit 1 discharge flume as a discharge path to Clinton Lake. The additional discharge flow from the EGC ESP facility would be insignificant relative to the capacity of the existing discharge flume. The CPS facility's safety-related systems and equipment would not be shared or cross-connected with the EGC ESP facility. However the EGC ESP facility would use the existing CPS ultimate heat sink as its source of makeup water.

The ESP facility might share some structures, such as the warehouse and training buildings and parking lots, with CPS. Some support facilities, such as the domestic water supply and sewage treatment, might also be shared. The applicant would expand the existing switchyard to accommodate the output of the new facility and to provide the necessary offsite power. EGC would use the switchyard area intended for the canceled CPS Unit 2 for this purpose. The applicant would also use the existing transmission right-of-way. SSAR Figure 1.2-4 identifies the location of the EGC ESP facility's new structures relative to the existing CPS facilities.

1.3 Plant Parameter Envelope

The regulations at 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," and 10 CFR Part 100, "Reactor Site Criteria," that apply to an ESP do not require an ESP applicant to provide specific design information. However, some design information may be required to address 10 CFR 52.17(a)(1), which calls for "an analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site under the radiological consequence evaluation factors identified in § 50.34(a)(1) of this chapter."

In Section 1.4 of the SSAR, the applicant provided a list of postulated design parameters, referred to as the "plant parameter envelope." The applicant states that the PPE is a set of design parameters that are expected to bound the characteristics of a reactor or reactors that might later be deployed at a site. This means that the design characteristics of potential designs would be no more demanding from a site suitability perspective than the bounding design parameters listed in the PPE tabulation.

The applicant states that it developed the list of plant parameters necessary to define the plant-site interface based on previous industry and Department of Energy-sponsored work performed in the early 1990s as part of the ESP Demonstration Program, as well as on current reactor vendor design input data. As a result of earlier and current efforts, the applicant identified appropriate design parameters to include in the PPE through a systematic review of regulatory criteria and guidance, ESP application content requirements, and experience with previous site suitability studies. The plant parameters characterize (1) the functional or operational needs of the plant from the site's natural or environmental resources, (2) the plant's impact on the site

and surrounding environs, and (3) the site-imposed requirements on the plant. The PPE values are generally based on certified design information and the best available information for as yet uncertified designs. Some of the values have been modified to include margin.

A set of plant parameter values is developed by considering the values provided by various reactor vendors and by applying appropriate conservatism where required to characterize the surrogate facility. As applicable, the most limiting (maximum or minimum) bounding value is selected. The complete set of plant parameter values describes, or envelops, the site-facility interface. This type of facility characterization is considered sufficient to assess the future use of the site for a nuclear electric generating facility.

Tables 1.4-1 through 1.4-8 of the applicant's SSAR list the parameters used, the PPE values selected, and the site characteristic values used in assessing the safety and environmental impact of constructing and operating the EGC ESP facility. SSAR Table 1.4-9 provides a description or definition and bases for the plant parameters used to evaluate the safety and/or environmental impact of locating the proposed nuclear generating capacity at the EGC ESP site.

The applicant has stated that through the PPE, it had sufficient design information to allow it to perform the evaluation required by 10 CFR 52.17(a)(1) to determine the adequacy of the proposed exclusion area and low-population zone (LPZ) for the site. Section 3.3 of the SSAR reports the results of this evaluation in which the applicant used design information limited to the release rate of radioactivity to the environment resulting from a design-basis accident for hypothetical reactors similar to two representative reactor types that vendors have offered for construction in the United States.

In addition to the information required to support the dose consequence evaluation, the applicant provides other design information in the PPE. Because the applicant is not requesting the issuance of an ESP referencing a particular reactor design, the staff's review criterion for the PPE is that the PPE values should not be unreasonable for a reactor that might be constructed on the ESP site. The applicant's PPE is based on various reactor designs that are either certified by the NRC, are in the certification process, or may be submitted for certification in the future. The PPE references the following designs:

- Advanced Canada Deuterium Uranium (CANDU) Reactor (ACR-700) (Atomic Energy of Canada, Ltd.)
- Advanced Boiling Water Reactor (ABWR) (General Electric)
- Advanced Plant 1000 (AP1000) (Westinghouse Electric Company)
- Economic and Simplified Boiling Water Reactor (ESBWR) (General Electric)
- Gas Turbine Modular Helium Reactor (GT-MHR) (General Atomics)
- International Reactor Innovative and Secure Project (IRIS) (consortium led by Westinghouse)
- Pebble Bed Modular Reactor (PBMR (Pty) Ltd.)

The staff reviewed the applicant's PPE values and found them to be reasonable, as discussed in the individual sections in this SER. As previously noted, the applicant identified certain PPE values as appropriate for inclusion in an ESP, if one is issued. The staff also reviewed the applicant's proposed list of PPE values and identified certain PPE values as bounding parameters or controlling PPE values as discussed in the individual sections of this SER. A controlling PPE value, or bounding parameter value, is one that necessarily depends on a site characteristic. As the PPE is intended to bound multiple reactor designs, the NRC would review the actual design selected in a COL or construction permit (CP) application referencing any ESP that might be issued in connection with this application to ensure that the design falls within the bounding parameter values. Appendix A to this SER lists the bounding parameters identified for the EGC ESP site.

If an ESP is issued for the EGC ESP site, an entity may wish to reference the ESP, as well as a certified design, in a COL or CP application. Such a COL or CP applicant must demonstrate that the site characteristics established in the ESP bound the postulated site parameters established for the chosen design and that the design characteristics of the chosen design fall within the bounding parameter values specified in the ESP. Otherwise, the COL or CP applicant must demonstrate that the new design, given the site characteristics in the ESP, complies with the Commission's regulations. If an entity wishes to reference the ESP and a design that is not certified, the COL or CP applicant must demonstrate that the design characteristics of the chosen design, in conjunction with the site characteristics established for the ESP, comply with the Commission's regulations.

1.4 Identification of Agents and Contractors

EGC is the applicant for the ESP and has been the only participant in the review of the suitability of the EGC ESP site for a nuclear power plant. CH2MHILL, under contract with EGC, served as the primary contractor for the development of the ESP application, supplying personnel, systems, and project management.

Several subcontractors also assisted in the development of EGC's ESP application. Parsons Power Group, Inc., provided engineering services in preparing the SSAR; Testing Service Corporation provided engineering, technical, and laboratory services associated with geotechnical activities; Geomatrix Consultants, Inc., performed seismic and geologic data collection, site response studies, and safe-shutdown earthquake determinations; GRL Engineers, Inc., conducted standard penetration test measurement work; Stratigraphics performed cone penetrometer measurements and testing for the geotechnical aspects of the ESP; and the University of Texas performed soil sample resonant column and torsional shear testing.

1.5 Summary of Principal Review Matters

This SER summarizes the results of the NRC staff's technical evaluation of the EGC ESP site. The staff's evaluation included a technical review of the information and data the applicant submitted, with emphasis on the following matters:

- population density and land use characteristics of the site environs and the physical characteristics of the site, including seismology, meteorology, geology, and hydrology, to evaluate whether these characteristics were adequately described and appropriately considered in determining whether the site characteristics are in accordance with the Commission's siting criteria (10 CFR Part 100, Subpart B, "Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997")
- potential hazards of man-made facilities and activities to a nuclear power plant or plants that might be constructed on the ESP site (e.g., mishaps involving storage of hazardous materials (toxic chemicals, explosives), transportation accidents (aircraft, marine traffic, railways, pipelines), and the existing nuclear power plant at the nearby CPS)
- potential capability of the site to support the construction and operation of a nuclear power plant(s) with design parameters within the parameters specified in the applicant's PPE under the requirements of 10 CFR Parts 52 and 100
- suitability of the site for development of adequate physical security plans and measures for a nuclear power plant(s)
- proposed major features for a future emergency plan if an applicant decides to seek a license to construct and operate a nuclear power plant(s) on the ESP site, any significant impediments to the development of emergency plans for the EGC ESP site, and a description of contacts and arrangements made with Federal, State, and local government agencies with emergency planning responsibilities
- quality assurance measures EGC applied to the information submitted in support of the ESP application and safety assessment
- the acceptability of the applicant's proposed exclusion area and LPZ under the dose consequence evaluation factors of 10 CFR 50.34(a)(1)

During its review, the staff held several meetings with representatives of EGC and its contractors and consultants to discuss various technical matters related to the staff's review of the EGC ESP site (refer to Appendix B to this report). The staff also visited the site to evaluate safety matters.

1.6 Summary of Open and Confirmatory Items

As a result of its review of Exelon's application for the EGC ESP, the staff identified several issues that remained open at the time the DSER and supplemental DSER were issued. The staff considers an issue to be open if the applicant has not provided requested information and the staff is unaware of what will ultimately be included in the applicant's response. For tracking purposes the staff assigned each of these issues a unique identifying number that indicates the section of this report describing it. The resolution of each open item is discussed in the SER section in which the item appears. For example, Section 2.1 of this report discusses Open Item 2.1-1.

In addition, the staff identified several confirmatory items in the DSER. An item is identified as confirmatory if the staff and the applicant have agreed on a resolution of the particular item, but the resolution has not yet been formally documented. For example, Section 1.1 of this report discusses Confirmatory Items 1.1-1 and 1.1-2.

The DSER was issued with 33 open items and 5 confirmatory items; the supplemental DSER was issued with 7 open items. As set forth in this report, all open items have been resolved and the confirmatory items have been completed. This SER documents the resolution of all the open and confirmatory items identified in the DSER and the supplemental DSER.

1.7 Summary of Combined License Action Items

The staff has also identified certain site-related items that will need to be addressed at the COL or CP stage if a COL or CP applicant desires to construct one or more new nuclear reactors on the EGC ESP site. This report refers to these items as COL action items. The COL action items relate to issues that are outside the scope of this SER. The COL action items do not establish requirements; rather, they identify an acceptable set of information to be included in the site-specific portion of the safety analysis report submitted by a COL or CP applicant referencing the EGC ESP. An applicant for a COL or CP should address each of these items in its application. The applicant may deviate from or omit these items, provided that the COL or CP application identifies and justifies the deviation or omission. The staff determined that the COL action items do not affect its regulatory findings at the ESP stage and are, for reasons specified in this report for each item, more appropriately addressed at later stages in the licensing process.

The DSER was issued with nine COL action items and the supplemental DSER was issued with eight COL action items. The staff reviewed the applicant's responses to the DSER and supplemental DSER open items and identified a number of new COL action items as a result. This report highlights these COL action items, and the staff explains them in the applicable sections of this SER. Appendix A to this SER includes a list of COL action items that must be addressed by a future COL or CP applicant. The staff identified COL action items in order to ensure that particular significant issues are tracked and considered during the COL or CP stage. The COL action items focus on matters that may be significant in any COL or CP application referencing the ESP for the EGC site, if one is issued. Usually, COL action items are not necessary for issues covered by permit conditions or explicitly covered by the bounding parameters. The list of COL action items is not exhaustive.

1.8 Summary of Permit Conditions

The staff has identified certain permit conditions that it will recommend the Commission impose, if an ESP is issued to the applicant. Appendix A to this SER summarizes these conditions. These permit conditions, or limitations on the ESP, are based on the provisions of 10 CFR 52.24, "Issuance of Early Site Permit."

The staff proposed 14 permit conditions in the DSER and 1 permit condition in the supplemental DSER. The applicant's responses to the DSER and supplemental DSER open items resulted in the resolution of some proposed DSER permit conditions. In addition, the staff determined that a permit condition is not necessary when an existing NRC regulation requires a

future regulatory review and approval process to ensure adequate safety during design, construction, or inspection activities for a new plant. Based on this criterion, the staff removed a number of permit conditions proposed in the DSER and, in some cases, added new permit conditions, COL action items, or site characteristics, as appropriate, to account for the concern.

Appendix A to this SER contains the final list of permit conditions, which have been highlighted throughout this report. Each permit condition has been reassigned a number identifying the order which appears in this SER. The staff has provided an explanation of each permit condition in the applicable section of this report.