Identifying and Characterizing Candidate Areas for Siting New Nuclear Capacity in the United States

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INTRODUCTION

Oak Ridge National Laboratory (ORNL) staff recently completed an internal "Energy Assurance" study examining the key issues associated with the country's energy needs for the future focusing on generation sources, baseload options, transmission and distribution, reduction of greenhouse gases, and overall energy security issues. In examining the various generation sources including nuclear power and renewables, one principal finding was that 300 GW(e) of new nuclear electrical generating capacity would be needed by 2050. With that need, the initial, obvious question is can 300 GW(e) of nuclear capacity be sited in the United States? In an attempt to address that question as well as others, ORNL initiated a "National Electric Generation Siting Study," which is to be a multiphase study to address several key questions related to our national electrical energy supply. The initial phase of this study is to examine the nuclear option. This paper summarizes the approach developed for screening sites, the methodology employed that includes spatial modeling, and preliminary results using the southeast United States to demonstrate the usefulness of the overall approach as a test case.

REACTOR SITING APPROACH AND METHODOLOGY

The objective in structuring the approach for this study was to use industry-accepted practices in screening sites and then to employ the array of data sources and considerable computational capabilities including geographical information systems (GIS) resident at ORNL to identify candidate areas. Essentially, we have (1) adapted and extended the 2002 Electric Power Research Institute (EPRI) Siting Guide[1] methodology developed to support early site applications (ESP) for purposes of screening sites and (2) employed three of the four steps in the Bechtel[2] site evaluation process. The EPRI screening process makes use of exclusionary, avoidance, and suitability criteria. The exclusionary criteria are "go or no go" site parameters that preclude siting a reactor due to an environmental, regulatory, or land-use constraint. The avoidance criteria assist in identifying less favorable areas such as proximity to hazardous operations. Both the exclusionary and avoidance criteria drive one away from sites. At this point the suitability criteria are employed to assist in evaluating the acceptability of candidate areas and sites. The Bechtel evaluation process includes a successive four-step approach examining first regions of the country, then regions of interest based on electricity and market projections, identifying candidate areas, and identifying candidate sites using various scoring and weighting factors.

The focus of the ORNL nuclear siting study is on identifying candidate areas from which potential sites might be selected stopping short of performing any detailed site evaluations or comparisons. This approach is designed to quickly screen for and characterize candidate areas. In consideration of the two aforementioned references, data presented in the 1993 ESP Demonstration Program,[3] and the ESP applications for North Anna, Clinton, and Grand Gulf sites, we developed a subset of plant parameter envelope (PPE) criteria considered as having the most impact on the viability of any given site and that were directly amenable to application of GIS techniques. This subset of PPE criteria and their respective values where appropriate are:

- population density (less than 500 people/square mile)—exclusionary;
- safe shutdown earthquake (peak ground acceleration greater than 0.3)—exclusionary;
- wetlands/open water—exclusionary;
- protected lands (national parks, historic areas, wildlife refuges, etc.)—exclusionary;
- slope of land (greater than 12%)—exclusionary;
- landslide hazard (moderate/high susceptibility)—exclusionary;
- 100-year floodplain locations—exclusionary;
- cooling water makeup sources: areas greater than 20 miles from sources with
    - 500,000 gpm for large reactor—exclusionary and
    - 100,000 gpm for small reactor—exclusionary; and
- locations in proximity of hazardous facilities—avoidance (can vary buffer zones)
    - major airports—10 mile buffer zone and
    - military bases, oil pipelines, refineries, oil/gas storage, etc.—5 mile buffer zone.

Note that the values for cooling water sources are based upon cooling requirements under either normal or accident conditions with the proviso that no more than 10% of flow is diverted from an existing source.

Using GIS techniques and GIS data sources such as from the U.S. Geological Survey and U.S. Federal Emergency Management Administration, each of these eight exclusionary and one avoidance criteria were successively applied as individual screening layers on the southeastern (SE) United States to create a composite view of potential areas of interest. Specifically, the Southeast Reliability Corporation and Florida Reliability Coordinating Council regions of the North American Electric Reliability Corporation (NERC) were selected initially for study since most of the new nuclear power plants for which license applications have been submitted are to be located in the SE and to limit the amount of data to handle as part of this demonstration.

The next step then was to look for (1) contiguous 500 acre sites for the large reactor and 50 acre sites for the small reactor meeting all criteria to form the Exclusion Area Boundary (EAB) and (2) sites within 25 miles of an electrical transmission line. The objective here was to distinguish what EAB areas may be suitable for siting a small reactor versus a large reactor as well as incorporating consideration of potential, available transmission lines. Actual plant sites would likely be larger, but not all the land needs to meet all the siting criteria. In the GIS spatial modeling process, 100 m by 100 m cell sizes were created. For a given area to be identified as a candidate siting area, it must first pass the eight exclusion/one avoidance criteria screening and then have each adjacent 100 m by 100 m cell (within the 500 or 50 acre areas) pass the criteria as well.

RESULTS FROM TEST CASE ON SE UNITED STATES

The above noted criteria were applied as indicated on the two NERC regions, which total approximately 370 million acres. Figure 1 shows the GIS results in terms of available land after the exclusions were applied.

Analysis of this "base map" yields the following results:

- for the large reactor with the 500,000 gpm and 500 acre requirements, approximately 9% of the SE region was identified as candidate areas for further examination;
- for the small reactor with the 100,000 gpm and 50 acre requirements, approximately 27% of the same are was identified as candidates for further examination;
- thus, there were three times as much land mass suitable for the small reactor versus the large one; and

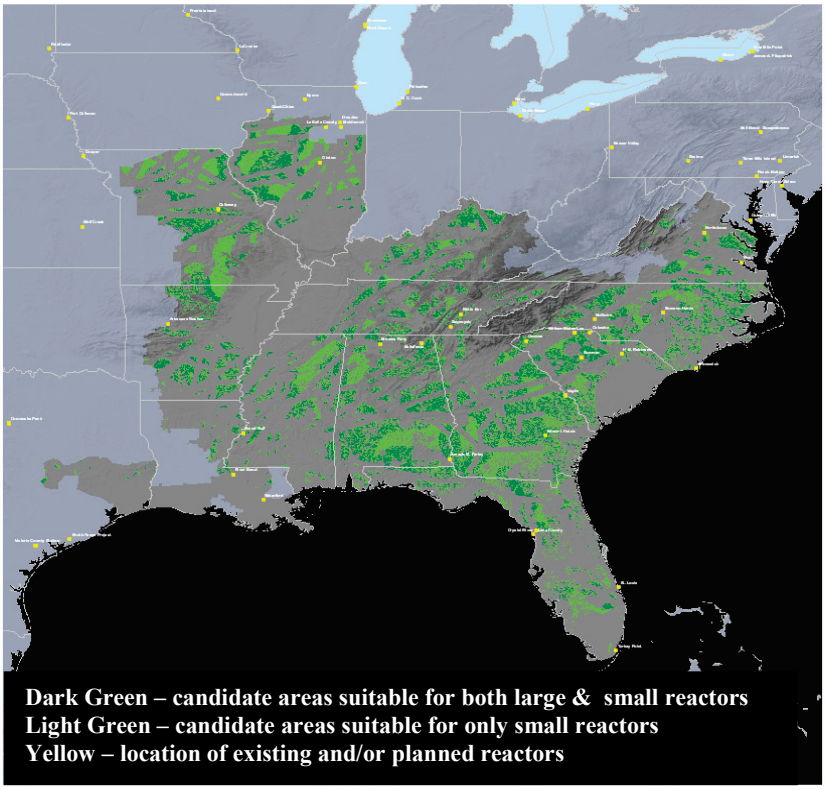

Fig 1. Composite GIS view for candidate areas for both large and small reactors in SE.

- all existing and planned reactor sites passed the eight exclusion criteria. Application of the one avoidance criteria on proximity to hazardous operations at the stated buffer zones in some cases removed existing and/or planned sites from consideration. Again, avoidance criteria are precautionary in nature. Also, reducing the buffer zones somewhat then yielded results where the existing or planned sites were included in candidate areas.

Additional analysis performed included examining candidate areas with population densities at 200 people per square mile, cooling water sources with 1,000,000 gpm, distance to transmission lines within at least 12 miles, and then overlaying the base map with the location of excess electrical line transmission capacity from 335 MW(e) to 1600 MW(e).

FOLLOW-ON WORK PLANNED

Upon successful completion of this test case with the SE, the following activities are planned.

- Engagement of an advisory panel that includes utilities, a reactor vendor, state agencies, and a nuclear industry organization to provide feedback on the approach, screening criteria, and values used.
- Expand the "base map" beyond the SE to include the entire United States/
- Examine what the potential is for adding additional capacity at existing sites.
- Perform some water shed thermal analysis to understand what candidate areas are eliminated once a plant is sited at a particular location.

REFERENCES

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3. Early Site Permit Demonstration Program Plant Parameters Envelopes—Comparison with Ranges of Values for Four Hypothetical Sites, SNL/NM-699795-2, Volume II, Revision 2 (September 1992).