KENTUCKY ALTERNATIVE ENERGY SITE BANK EVALUATION

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Department for Energy Development & Independence

Energy and Environment Cabinet
Commonwealth of Kentucky

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1.0 INTRODUCTION

Kentucky is uniquely situated to be in the forefront of the nation's energy future. The State has an abundance of natural and intellectual resources. We have fossil fuels such as coal, natural gas, tar sands, oil shale, and a vibrant agricultural and silvaculture industry. Kentucky is blessed with a proven workforce and research facilities focused on energy development and efficiency at the University of Kentucky, University of Louisville, Murray State University, Eastern Kentucky University, and Western Kentucky University. Our State government is united in support for the concept of energy independence for the United States. Geographically, Kentucky's central location and access to infrastructure such as the rail and road transportation network, interstate natural gas pipelines and several electricity markets are opportunities that ensure the value of these natural and intellectual assets.

However, much of Kentucky's energy needs are met with fossil fuels (greater than 95% electricity production from fossil fuels). Our industrial base relies heavily on energy costs which are lower than most of the rest of the nation. With the promise of dramatically higher energy costs due to pending carbon constraining legislation, and the acknowledged goal of reducing Kentucky's carbon footprint, new and better ways of meeting our energy needs are required.

The urgency of this need drives the Energy Project Site Bank effort as we learn what essential factors must be present for success in developing new and improved forms of energy. Our view includes traditional renewable energy sources like wind and solar, the promise of biomass, the use of coal in new and clean ways to produce liquid fuels, synthetic natural gas and power, and potentially, the use of nuclear technology.

Why did we develop the Site Bank?

In 2006, the Kentucky Legislature and the Executive Branch united to pass the Kentucky Energy Security and National Leadership Act (HB299). HB299 required the former Office of Energy Policy (OEP) to develop and implement a strategy for production of transportation fuels and synthetic natural gas from fossil energy and biomass resources. As a result, the "Site Bank" process was born. The goal was to identify sites capable of accommodating a plant having at least 10,000 barrels per day output in liquid fuels, or the equivalent thousands of cubic feet per day of pipeline quality synthetic natural gas, referred to generally as coal-to-liquids/coal-to-gas (CTL/CTG) facilities. In late summer 2007, State leadership again united to pass House Bill 1 (HB1) which initiated research into carbon sequestration and encouraged other projects, like the continuation of the Site Bank project. Over a period of two years, the Kentucky CTL/CTG Site Bank evaluation process examined forty-one (41) sites, several of which have been and continue to be the subject of significant developer interest.

In the 2008 Regular Session of the General Assembly, the focus on energy issues continued, with House Bill 2 (HB2) providing further initiatives for renewable energy technologies and increased energy efficiency. In June 2008, Governor Beshear initiated a reorganization of the executive branch, resulting in the Energy and Environment Cabinet (EEC) of which the Department of Energy Development and Independence (DEDI) is a critical part. The functions of the former OEP have been assumed by the DEDI. The organization was given its mandate with the release of "Intelligent Energy Choices for Kentucky's Future: Kentucky's 7-Point Strategy for Energy Independence, in November 2008 (the Energy Strategy). The Energy Strategy is a road map for a journey to energy independence.

The 7 Strategies:

Strategy 1: Improve the energy efficiency of Kentucky's homes, buildings, industries and transportation fleet.
Goal: Energy efficiency will offset at least 18 percent of Kentucky's projected 2025 energy demand.

Strategy 2: Increase Kentucky's use of renewable energy
Goal: By 2025, Kentucky's renewable energy generation will triple to provide the equivalent of 1,000 megawatts of clean energy while continuing to produce safe, abundant and affordable food, feed and fiber.

Strategy 3: Sustainably grow Kentucky's production of biofuels
Goal: By 2025, Kentucky will derive from biofuels 12 percent of its motor fuels demand, while continuing to produce safe, abundant and affordable food, feed and fiber.

Strategy 4: Develop a coal-to-liquids industry in Kentucky to replace petroleum-based liquids
Goal: Kentucky will develop a coal-to-liquids industry that will use 50 million tons of coal per year to produce four billion gallons of liquid fuel per year by 2025.

Strategy 5: Implement a major and comprehensive effort to increase gas supplies, including coal-to-gas in Kentucky
Goal: Kentucky will produce the equivalent of 100 percent of our annual natural gas requirement by 2025 by augmenting in-state natural gas production with synthetic natural gas from coal-to-gas processing.

Strategy 6: Initiate aggressive carbon capture/sequestration projects for coal-generated electricity in Kentucky
Goal: By 2025, Kentucky will have evaluated and deployed technologies for carbon management, with use in 50 percent of our coal-based energy applications.

Strategy 7: Examine the use of nuclear power for electricity generation in Kentucky
Goal: Nuclear power will be an important and growing component of the nation's energy mix and Kentucky must decide whether nuclear power will become a significant part of meeting the state's energy needs by 2025.

Information developed during the initial stages of the Site Bank project will help achieve the goals associated with Strategies 4 and 5, and by analyzing carbon sequestration potential as part of the site analysis, will help further the goal of Strategy 6 as well.

This report addresses goals associated with Strategies 2, 3 and 7 by assessing how the sites previously evaluated for CTL/CTG may fit into the need to increase the development of renewable energy sources, increase the production of biofuels and inform the conversation and decisions about the use of nuclear power in our State. In addition to clean coal alternatives, this newest assessment indicates that Kentucky has properties and infrastructure which may be suitable for biomass and nuclear electricity generation. For some of the alternatives reviewed, additional study is required to accurately assess the potential for success with technology generally available. It is also clear that there are sites which are not appropriate for the alternative technologies.

This report does not indicate that these sites are currently being developed for the several technologies reviewed. In particular, in furtherance of Strategy 7, the sites were evaluated against nuclear siting criteria to inform the discussion as to what a suitable nuclear site MIGHT look like.

The evaluations were performed with the permission and assistance of the site sponsors. Additionally, each County Judge Executive was informed of the project at the inception, in order to ensure an open process.

This report contains background information regarding the Site Bank concept, the five assessment criteria, the resources consulted, and information on the sites reviewed. In following sections we describe the criteria used to evaluate the sites for each of the types of renewable technologies, solar, wind, biomass, as well as for nuclear power. We explain the critical resources identified for each technology. We have included a summary outlining the results of the evaluations and identifying those sites which appear best suited for the different technologies. And we discuss the areas which appear, to us, to be ripe for further study or development to move toward the goals in Kentucky's Energy Strategy.

2.0 SITE BANK PROCESS

History

The Site Bank process began in 2006 with a call from the former OEP to all County Judge Executives, Legislators and Area Development Districts (ADD) staff, and to selected mineral and energy industry representatives, to nominate sites likely to succeed as energy facilities. The first effort resulted in review of 19 sites across Kentucky. The process was repeated the following year and netted an additional 22 sites. These first two rounds focused on CTL/CTG technology only. The evaluations and review have resulted in substantial development interest in several of the sites. For example, one is currently being used to investigate biomass, and another has proceeded through process selection and preliminary design for a CTG facility.

The evaluation process was established during Site Bank I and has continued, with modifications and updates, through the remaining investigations. Criteria for siting a facility were established, taking into account the general needs of a large industrial development, as well as the technology specific aspects of the energy facilities imagined. The site sponsors worked with SMG to find and develop as much information as possible addressing those criteria. Public data was accessed and reviewed, including environmental database searches, threatened and endangered species, National Register of Historic Places, oil and gas records, soil surveys, geologic maps, state and national parks and reserves, wilderness areas and trails, to name a few. SMG consulted with the Kentucky Geologic Survey (KGS) to develop a comprehensive assessment of sequestration potential, as well as a more general geologic profile of each site, addressing oil and gas availability, seismic stability and faulting. The Kentucky Heritage Council was consulted with regard to each site to determine if any listed sites were present or likely to be directly impacted by development. An assessment of water resources was conducted, looking both at availability and quality.

At least one site visit was made to each site to obtain photographs representing the site and to confirm and supplement information provided by the sponsor and from public records. Compilation of all the information gathered was part of the scoring of the site, utilizing the criteria developed for the energy technology. Finally, a report was produced for each site, describing the assets and limitations of the site and its ranking among the reviewed sites.

In addition to the site reports, each Site Bank project has also resulted in some extra value to the State. A web site has been designed, redesigned and built which allows public access to information about the sites. The website files are delivered with this report for transfer and loading to the State's web access. A permit map was developed which describes in some detail, most of the permits which would be required for CTL/CTG development. The permit map was delivered both electronically, with links to resource sites, forms and other required documents, and as a hard copy with associated forms included. The timeframes associated with permitting such a facility were depicted on a Gantt Chart, showing both the regulatory timeframes and those which experience indicates will be encountered.

Site Bank III

The original scope of work for Site Bank III contemplated re-evaluation of thirty-two of the forty-one sites identified and reviewed during Site Bank I and Site Bank II. After initial review and evaluation of the process, SMG agreed with DEDI that forty of the sites would be included in the Site Bank III review. (One of the original sites is a subset of another and is therefore included as well.)

This project has always depended, to a great extent, on the cooperation and interest of the site sponsors and the local public officials and economic development professionals in each area of the state. In order to maximize their input, SMG provided a letter to each site sponsor for each of the sites previously evaluated, notifying them of the new project and explaining the alternative energy

focus. Several of the sponsors contacted SMG to express their interest in proceeding with the project.

Additionally, SMG contacted each County Judge Executive in whose county a site is located to ensure that they were aware and supportive of the effort. The engagement of these individuals allows the development of more accurate information and provides a means of informing those interested of the efforts of the DEDI to encourage energy projects across the Commonwealth. Interestingly, the Site Bank III project commencement coincided with the release of the Governor's Energy Strategy and SMG engaged in numerous discussions with the Sponsors and local officials about the strategies and their importance to the economic future of Kentucky.

Substantial research was performed, utilizing the Renewable Energy Inventory as a starting point for solar and wind technologies, and making extensive use of reports available through the Department of Energy and its research agencies. A list of resources reviewed is included in **Appendix A.**

In consultation with Engineering Consulting Services, Inc. (ECSI), SMG developed criteria for evaluation of the previously nominated sites for nuclear, biomass, solar and wind technologies. These criteria identify the factors which are critical, necessary or important to the successful development of those technologies. In certain cases, "fatal flaw" aspects were identified and are discussed later in this report. The criteria were shared with DEDI staff to elicit comments and suggestions, which were incorporated. Copies of the final criteria are included as **Appendix B**.

The next step in the process was to review all information on hand for each of the 40 sites against the four new criteria. In that process, we took the opportunity to upgrade some of the information previously obtained. For example, we

upgraded the available information with regard to water resources for the initial 19 sites to conform to the more extensive information developed during the second round of evaluations. Water will be an essential element of evaluation for potential nuclear and biomass sites, as it is for CTL/CTG sites.

Following review of information already in hand, SMG identified "data gaps" caused by the need to evaluate the site in a different way for different technologies. These gaps were discussed in a letter to each sponsor, requesting the additional information. Following receipt of whatever information became available; the sites were scored and ranked. Throughout the process, the criteria were reviewed to ensure that their application was consistent and the resulting analysis was supportable. Minor changes and adjustments were made as the result of discussions with DEDI staff and as anomalies were identified.

Following discussions with DEDI staff, a one-page fact sheet was developed for each site, briefly describing the site's assets and limitations and providing mapping and other data. The addition of this format adds value to the project by providing a short summary of the assets and limitation of each site.

All of the data gathered was used to compile a narrative report about each site, supplemented with appropriate appendices. The reports were provided to DEDI and to the site sponsors for review and comment. The final site reports reflect comments received. One hard copy of the report, the appendices and the fact sheet, together with an electronic copy of each, has been provided to the site sponsors, concurrent with the conclusion of this project. A copy of each of the site reports, appendices and fact sheets are submitted to DEDI with this report.

3.0 CRITERIA

The site evaluations are based on five sets of criteria that reflect information developed in research and in reports about the operation of CTL/CTG, biomass, wind, solar and nuclear facilities around the world. Information regarding inputs and outputs for each type of technology was gathered and incorporated along with basic site needs. Relative weighting was applied to those criteria that were determined to be particularly important or for which significant cost could be expected. The goal of the criteria and associated evaluation was to determine which sites were most ready and most suitable for development at this time.

The criteria were established by first looking to the physical characteristics such as size, location, and environmental condition that are beneficial to a successful facility of each type reviewed. Other aspects of the site that may be detrimental or cost–prohibitive, such as potential environmental impacts to water quality or threatened and endangered species were considered. Sensitive conditions such as wetlands and floodplains were also reviewed to ensure that the proposed facility would be technically, legally, and environmentally feasible. The needs of each type of facility for feedstock, power, transportation, and workforce were factored as well. Following is a brief discussion first of the common aspects of the criteria applicable to most sites, and a more detailed discussion of technology specific needs which were used to develop specific criteria for each technology.

Numerous individuals and organizations have contributed to the development of the criteria over the past three years. Reports from independent organizations, as well as government sponsored research were used. Handbooks and manuals from organizations promoting a particular technology were reviewed. A listing of the sources accessed and utilized is included as **Appendix A** to this report.

Critical Resources/Fatal Flaw

For each energy technology considered, there are important and necessary resources that must be available in order for a site to be successful. In some cases, a resource or requirement was identified that is so essential to the operation of a technology that a site cannot be successful if that aspect is lacking. For example, adequate water is essential for cooling purposes at a nuclear power plant.

Evaluating forty sites for four technologies, in addition to the evaluation already performed for CTL/CTG, is a complex task with time and budget constraints. In addressing that complexity, in cases where one resource was identified as critical, the potential for a "fatal flaw" was evaluated before proceeding with the application of the full criteria. For example, because adequate water resources were determined to be the critical resource for nuclear power generation, the first step in reviewing a site for potential as a nuclear facility was to determine the volume and availability of water. If adequate water was not present, the "fatal flaw" for nuclear potential was identified and the site was not evaluated under the nuclear criteria further. Discussion of the critical resources associated with each of the technologies is included when the individual criteria are discussed.

3.1 Common Criteria

Physical Characteristics of the Site

The relative size of the site was evaluated, specific to each energy technology. For example, CTL/CTG, nuclear and biomass require a larger site than solar or wind. This criteria addresses the need for large critical core infrastructure and facilities to manage feedstock processing, ancillary equipment, administrative areas and access areas or buffer zones.

The topography of the site was evaluated to rank the relative ease with which the site could be prepared for construction. Extensive earthwork would increase the cost of construction.

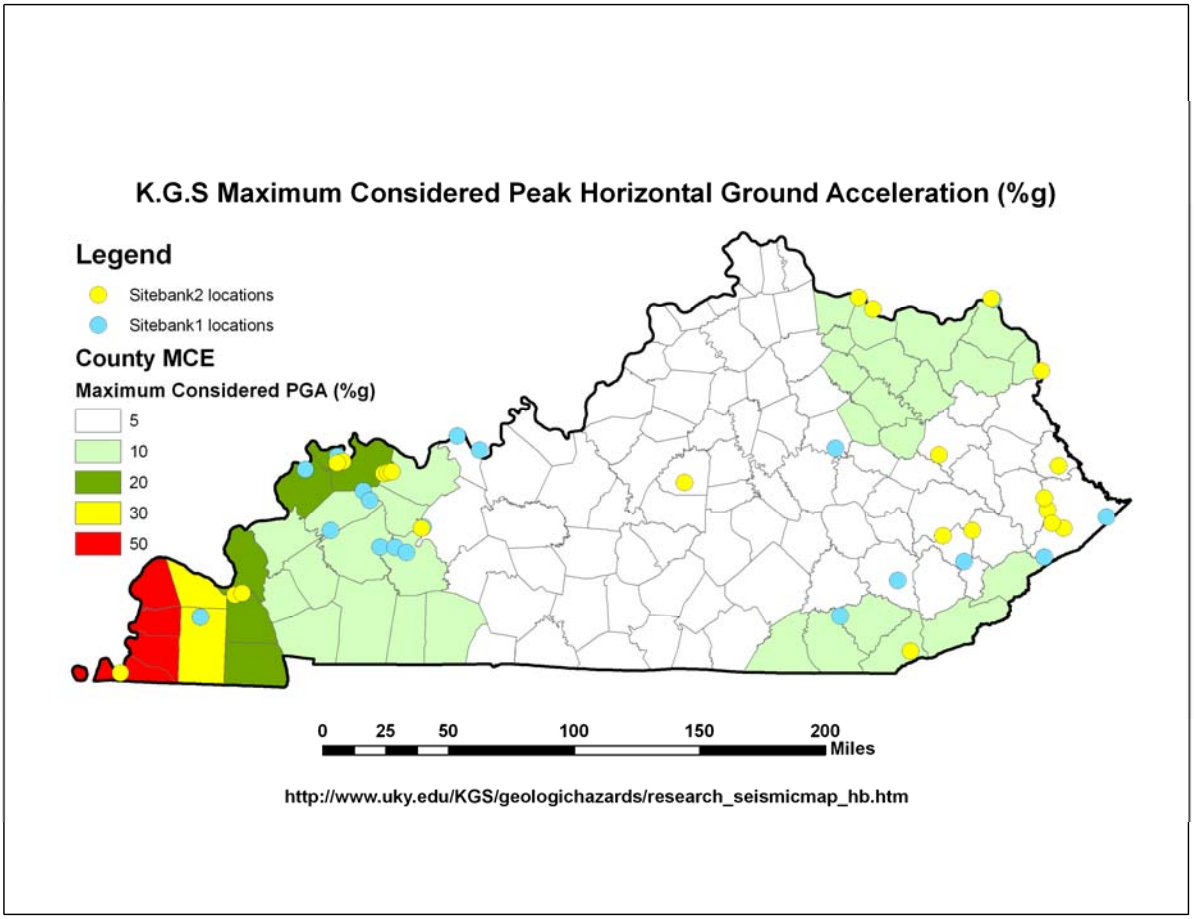
The ownership and control of the site was evaluated. A site that is offered by its fee owner is more immediately developable than one with multiple owners or with different owners of aspects such as mineral and surface.

Wetlands and floodplains can have a significant negative effect on a project in terms of permitting, limitations on land use, and development costs. Sites with limited or no impact from floodplains and wetlands are ranked higher than those with significant impact.

Geologic Factors

Geologic factors evaluated included basic geological questions as well as the potential for on-site or nearby carbon sequestration potential, where applicable. The KGS participated substantially in the drafting of the criteria for this section and in the evaluation of the sites. They have provided reports which have been incorporated into the site information presented.

The seismic risk of a site is ranked based on the KGS's seismic risk mapping data. Because of the significance of the issue, the KGS has been especially active in evaluating seismic risk. A detailed discussion of seismic risk in western Kentucky prepared by the KGS is included in **Appendix C** to this report. Sites with higher likelihood of peak ground acceleration are ranked lower than those with less risk. The following graphic map illustrates relative risk of seismic activity.



The potential for carbon sequestration is evaluated for those technologies where carbon capture and sequestration is expected to be required (CTL/CTG, potentially biomass). The factors considered include both positive features such as appropriate target formations and potential negative features such as an overly penetrated target formation. Specific aspects reviewed included the presence of oil fields within specific radii and at certain depths; the proximity of the site to target geologic formations likely to be acceptable sequestration receptors; the proximity of deep saline formations and their structure; the presence of seismic lines; the proximity of underground coal mines, limestone quarries, and similar facilities; and the number of times the target formation has been penetrated by boreholes or drilling for oil, gas or for other purposes in

proximity to the site. An additional factor in the geologic evaluation is the potential for faults in proximity to the site.

Other Site Characteristics

The likelihood that the site has been or may be impacted by environmental pollutants is a critical factor in the suitability for a facility. Existing environmental impacts could have a costly detrimental effect on a project or may make portions of the site unsuitable for development.

While the presence of an oil field may be beneficial for the purpose of sequestration potential, the presence of wells (operating or inactive) and gathering lines can be a cost to remove and properly close during development of a potential facility. Additionally, the presence of large transmission lines that may have to be relocated was assessed.

The existing land use of the proposed site and its surrounding area is important. Sites that are surrounded by residential land use will not be as highly rated as industrial land areas and in some cases will make the site unsuitable, as with nuclear facilities.

Basic infrastructure that will be required for site development of any kind is evaluated to determine how ready the site is for development. Aspects which are reviewed are the presence on-site of access roads, potable water, sewer service, basic electricity, and natural gas.

The presence of adequate roads is important for several reasons. Transportation of construction equipment, materials, and labor may be over roads accessing the site. Once the site is in operation, coal or biomass deliveries may be by road. Facilities with a substantial work force will need roads adequate for that traffic.

The condition, capacity, and route of the access roads will impact the success of the site.

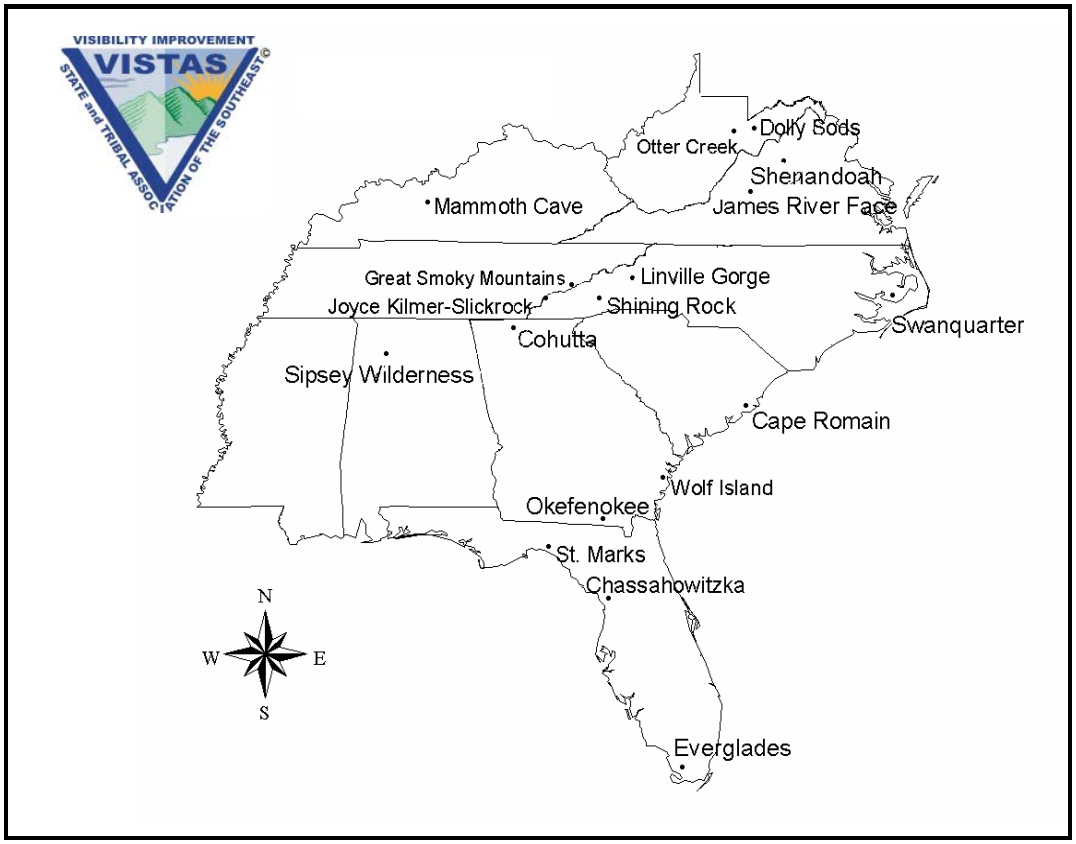
Regardless of the technology, the facility must have fast and reliable access to the internet through broadband in order to adequately operate and communicate.

Most energy facilities are expected to have structures that could impede low level flight. For example, if a flare is in use it can present a hazard to low-flying aircraft. The flare itself may not be visible during the day and therefore the close presence of an airfield is not beneficial. Glare from solar panels can be a hazard, as can the height of wind turbines.

Proximity to Sensitive Areas

Certain aspects carry a heightened sensitivity or regulatory impact. Wetlands and floodplains are two such aspects, but are addressed in the general site characteristics. Another aspect is the proximity of the proposed site to Public Access Areas. This term describes areas the public uses, primarily for recreational purposes. These areas include local, state, and national parks and nature preserves, federal wildlife refuges, federal wilderness areas, and federally designated wild and scenic rivers or study areas for any of the listed uses.

Proximity to Mandatory Class I Visibility Areas can impact the allowable air emissions and require modeling for any energy facility required to obtain an air pollution discharge permit. The Class I areas in or closest to Kentucky are Mammoth Cave and the Great Smoky Mountains National Park. The following map shows the Mandatory Class I Visibility Areas in the southeastern United States.



The presence of threatened and endangered species or their habitat on the project site may make the site inappropriate for development. The sites were evaluated for occurrence of federally listed species within the appropriate United States Geological Survey 7.5-Minute Topographic Quadrangle. Additional evaluation and consultation with the United States Fish and Wildlife and Kentucky Fish and Wildlife would be required prior to development.

Cultural resources include both historic buildings and structures which appear on the National Register of Historic Places, sites eligible for listing and potential or documented archaeological sites which may hold significance for the history and culture of Kentucky and all its historic occupants. Basic review of listed sites is used to indicate the likelihood of a sensitive site on or within the area of potential effect, including visual effects. Resources used include basic database reports recognizing listed historic sites and a review of the state listings for the

appropriate county. Informal consultation with the Kentucky State Historic Preservation Officer indicates that many sites located in and around river floodplains may have pre-historic cultural sites. SMG consulted with the Kentucky Heritage Council to confirm the presence of assets on or within 100 meters of the sites.

Regulatory and Permitting Issues

Proximity to a non-attainment area will drive the complexity and control measures that will be required for air permitting. The relative location of non-attainment areas to the proposed sites was examined and evaluated. Maps depicting the Kentucky non-attainment areas by pollutant are included as **Appendix D**. Certain pollutants of the National Ambient Air Quality Standards are currently undergoing review and revision by EPA and we can expect that the non-attainment areas depicted in this report will change.

Water resources of the Commonwealth are reviewed to ascertain whether any of the sites are adjacent to or would be expected to discharge into an outstanding national resource water or an exceptional stream. If so, the site may be inappropriate for development unless it is possible to isolate the stream from any negative impact from the facility. The potential for impact from the facility on impaired waters was evaluated by determining the likelihood that discharge from the site would drain into or eventually reach either a high quality or impaired stream. Water discharges from the facilities would be subject to effluent limitations, just as all other industrial facilities are, with details outlined in a Kentucky Pollutant Discharge Elimination System (KPDES) permit. Information regarding stream classification was obtained from the Kentucky Division of Water.

Volume of Water Available

The processes used in CTL/CTG, biomass and nuclear facilities consume large quantities water. While a portion of that water stream will be recycled, a significant majority is lost to steam in the process. A reliable and adequate supply of water is essential to keep these plants running. Facilities with inadequate water available may be better suited for other types of energy development or CTL/CTG facilities that use air cooling methods.

Material and Fuel Delivery

CTL/CTG facilities will require adequate, cost-effective, and flexible access to coal and superior transportation options to move coal in and liquid or gas fuel and by-products out. Biomass facilities will face the same or greater needs with biomass feedstock which is less dense than coal.

Rail access to a site is examined to determine if a unit train siding is on or adjacent to the site. Rail delivery of coal or biomass also would allow rail transport of liquid fuels generated by the process.

Barge transport is an economical means of bringing materials in and product out. Proximity to a suitable barge facility or the ability to construct one at the site is an important aspect.

The flexibility to be able to use road, rail, and barge will help keep the facility competitive.

Natural gas may be necessary as a start-up fuel for certain of these technologies and should be available to a site at minimum volumes. Gas transmission pipelines near a site raise the possibility that syngas, processed to pipeline quality, can be sold and transmitted off site through pipelines.

Availability of Workforce

Certain of the facilities, i.e. nuclear, CTL/CTG and biomass, will involve a substantial workforce, first to build and then to operate. There is a need for construction trades in sufficient numbers that the available workforce is not strained. Operations will require a large number of skilled or professional workers to operate and manage the facility. The site must be able to pull from a large enough population to ensure an appropriate workforce for both aspects of the project. Solar and wind facilities will require few operational employees and a substantially smaller construction commitment. In order to use a consistent approach to workforce availability, workforce data maintained by the Kentucky Economic Development Cabinet was utilized. The Cabinet obtains this data from the U.S. Department of Labor, Bureau of Labor Statistics.

Transmission Criteria

The site must have adequate electrical power available. Additionally, because most of the potential energy facilities will be purposed to generate electrical power, or will generate electricity in excess of its own needs, proximity to a transmission point from which the excess electricity can be sold is essential. The sites are evaluated based on the size of power transmission proximate to the site, location of a suitable transmission point, and the availability of a right of way to connect the site to the necessary transmission grid.

The transmission criteria were based on assumptions about access to “the grid” in an area that is robust enough to reliably transfer the power from the proposed site to the load centers. The requirements increase as the capacity of the proposed generator increases. The appropriate transmission requirements are dependent on the capacity of the generation and not the type of fuel used to generate. However, base load, steam plants and nuclear plants require more reliability in the transmission system because of the cost and time necessary to stop and start the generating plant.

A 69 kilovolt (kV) line can be estimated to have a total capacity rating of 32 megawatts (MW) (MVA) under normal summer conditions and 72 MW (MVA) in winter. (Emergency conditions are 24 MW and 69 MW respectively).

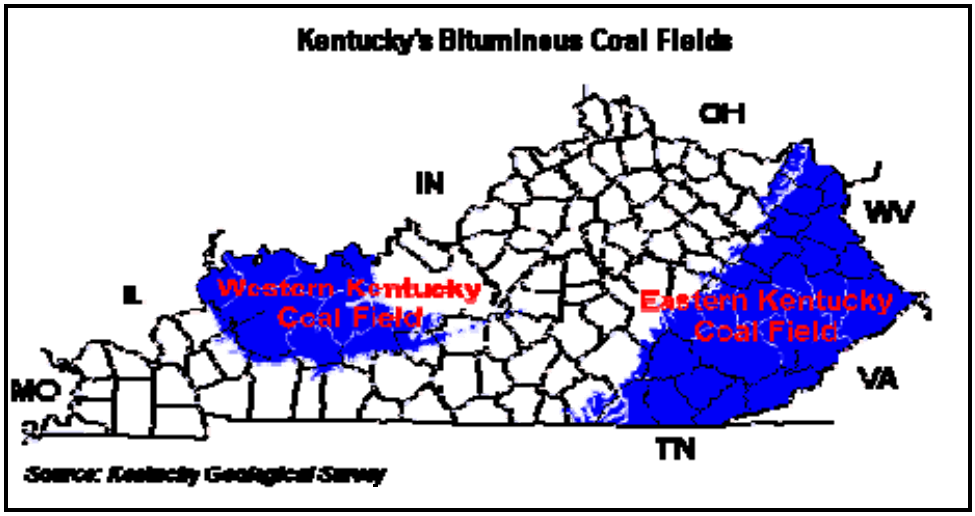
A 161 (or 138) kV line can be estimated to have a total capacity rating of 230 MW (MVA) under normal summer conditions and 170 MW (MVA) under emergency summer conditions.

The transmission line(s) to which the plant will connect must be able to carry its existing power plus the additional power from the proposed plant. The size and number of lines stated in the criteria was set to give an indication of the ability of "the grid" to accommodate the added generation. Multiple, high voltage lines within a reasonable distance indicates that there is likely connection to more load centers (power consumers). This both increases the number of potential power customers but also reduces the transmission upgrades that the new generator would have to fund.

A detailed transmission study will be required for any proposed generation connection to the transmission system to determine the systems capability to transfer the power from the proposed facility to its intended load.

3.2 Criteria Specific to CTL/CTG

CTL/CTG criteria have been extensively discussed in earlier reports. A successful CTL/CTG facility will need substantial acreage to support the process equipment, coal delivery, handling and processing. The waste resulting from the gasification process will be sent off site for beneficial reuse or must be disposed of, either by the facility or through a licensed third-party special waste landfill. If disposal in an on site landfill is the best option, additional acreage will be required. Due to the likelihood of carbon constraint legislation, carbon capture and sequestration may be important considerations and should be factored into the site selection.



Feed stock availability is of particular concern to a CTL/CTG plant. Access to coal feed stock will be influenced by the distance and transportation costs associated with reaching the facility. Sites within the coal fields are ranked

higher on this aspect, as are sites that will have multiple sources of coal and are not limited to a single supplier or a single transportation method.

Water resources are also a critical aspect of the success of a CTL/CTG facility with a minimum requirement of 2500 gallons per minute consistently available.

3.3 Criteria Specific to Nuclear Facilities

The siting criteria chosen for a nuclear generator was developed from the *Nuclear Regulatory Commission Regulatory Guide 4.7 - General Site Suitability Criteria for Nuclear Power Stations* (NRC RG 4.7) and general construction requirements. A generating facility with a nominal capacity between 1000 MW and 200 MW was considered in developing the criteria. Where the guide did not give values for criteria the NRC considers, those values were based on existing nuclear facilities and current applications before the NRC. (TVA's Bellefonte Nuclear Power Plant, Units 3 & 4, Alabama; Belle Bend Nuclear Power Plant, Pennsylvania; Grand Gulf Nuclear Station, Mississippi.)

The most critical asset evaluated for nuclear facilities is water. The need for a large and reliable source of water is so imperative it becomes a "fatal flaw" aspect, without which the site will not succeed. This requirement means that a nuclear facility can only succeed on one of Kentucky's major waterways.

Atmospheric Extremes

Regional weather patterns are an important factor to consider when selecting a site for a nuclear power facility. According to the NRC, tornadoes and exceptional icing conditions are the atmospheric extremes that warrant the most concern. The Site Bank III evaluations concentrated on tornado activity as the indicator for this criterion because they are more common to Kentucky than severe ice storms.

One of the major concerns associated with tornadoes are projectiles carried by high-speed winds, referred to as missiles, created when a loose object of considerable mass is propelled by wind forces exceeding 150 miles per hour. Such a missile could punch through the exterior wall of a nuclear facility and compromise its safety-related structures, endangering public health and safety. Safety-related structures, systems, and components can be designed to withstand most atmospheric extremes, but there is added cost necessary to reinforce such facilities.

This criterion was evaluated using a Federal Emergency Management Agency (FEMA) map of documented tornado occurrences within a defined area. This map shows the occurrence of documented tornadoes between the years 1950 and 1998 that ranked F3 or higher on the Fujita scale for every incremental area of 3,700 square miles. The greater the number of tornado occurrences the lower the ranking the site received.

Atmospheric Dispersion--Proximity to Industrial Plume

Dispersion characteristics attributed to a site are an important consideration for evaluating the ability of a nuclear facility to safely emit gaseous effluents. The emissions from a nuclear facility can be either routine releases of gaseous effluents or accidental releases of airborne radioactive material. Evaluation of a potential nuclear facility site must adhere to NRC requirements for emergency releases, as well as State and Federal requirements of the Clean Air Act.

Determining the suitability of a site based on dispersion factors is difficult without intensive data collection and computer air modeling. For the purposes of this preliminary evaluation, each site was evaluated based on the potential for nuclear power station emissions from this site to interact with noxious or toxic emissions or hazardous conditions associated with a nearby facility. Potentially hazardous facilities or activities include chemical plants, refineries, mining and quarrying operations, oil or gas wells and product storage installations that may

produce missiles, shock waves, flammable vapor clouds, toxic chemicals, or incendiary fragments.

The most effective method for determining the potential for such interactions is by locating emission points within a five (5) mile radius of the proposed site. The EPA EnviroMapper was used to determine recorded toxic releases, hazardous waste sites, and other potentially hazardous facilities that could interact with emissions from a nuclear power station with detrimental consequences. Sites with a hazardous facility within one (1) mile of the potential site received the lowest ranking, while sites with no facilities within five (5) miles received the highest ranking. Sites that have potentially hazardous facilities or activities located within 5 miles will require a detailed risk assessment of the site and appropriate design consideration in accordance with the NRC guidelines.

Geologic Factors

Surface faulting, earthquakes, and foundational stability are the most restrictive geologic factors in terms of properly engineered features and protecting public safety. Nuclear power stations must be designed to prevent the loss of safety-related functions that could be caused by these factors. Therefore, faults and seismic stability receive the second highest weighting for this evaluation.

- Faulting

The investigation of surface faulting near a potential nuclear facility site is required by the NRC to ensure there is minimal likelihood of earthquakes on faults within five (5) miles. Surface faults must be evaluated to determine their potential for surface displacement that would jeopardize the integrity of the structure and foundation of a potential nuclear power plant. According to 10 CFR 100 Appendix A(IV)(b), an investigation of surface faults greater than 1,000 feet long and within 5 miles of the proposed site is required to determine whether, and to what extent, the nuclear power plant will need to be designed for surface faulting.

For the purposes of this preliminary site evaluation, the site proximity to fault zones is considered with the potential seismic activity along that fault line. The preliminary evaluation of these factors provides an indication of the potential for surface displacement. The vibratory ground motion that results from seismic activity is referred to as Peak Ground Acceleration (PGA). PGA is the maximum horizontal acceleration experienced during the course of an earthquake. This measure is used to determine design standard necessary to construct a nuclear facility that can withstand seismic events. Therefore, potential sites that have a fault system within 5 miles and PGA greater than 5% g are considered high risk, thus receive the lowest ranking.

- Seismic Stability

The ability of the site foundation of a potential nuclear facility to resist seismic events can impact the structural integrity and general safety of a nuclear power plant in multiple ways. The stability of ground material can be compromised through liquefaction or subsidence, and sites located along large rivers could potentially experience earthquake-induced flooding. Therefore, the proposed site must have low risk from significant seismic events, which can be estimated using a scale referred to as Maximum Credible Earthquakes (MCE). The Maximum Credible Earthquake (MCE) is the largest hypothetical earthquake that may be reasonably expected to occur along a given fault or other seismic source under current tectonic setting. The MCE for locations throughout the United States has been evaluated by the U. S. Geological Survey (USGS) using all known geologic and seismologic data that demonstrate peak ground acceleration less than 20 percent g (acceleration due to gravity or m/s^2), with a 10 percent chance of exceedance in 50 years. The USGS National Seismic Hazard Maps (http://gldims.cr.usgs.gov/nshmp2008/viewer.htm) were used to estimate the MCE for sites evaluated for nuclear power stations. Site with an MCE of 30%g or higher received the lowest score, while 5%g or less was considered to be within an acceptable level of seismic activity.

- Depth to Bedrock

Similar to the construction of any large structure, thorough understanding of the geotechnical stability of a potential nuclear power station site is critical for preserving the safety functions of the facility. Sites with competent bedrock that is shallow relative to the ground surface generally have more suitable foundation conditions according to NRC Regulatory Guide 4.7C.1. Constructing a large facility on unstable site soils without competent bedrock can threaten the stability of the structure through subsidence and differential settling. The foundation design methods necessary to overcome insufficient geotechnical stability may be cost prohibitive and incur unnecessary risk. The depth to bedrock can sometimes be determined using USDA Soil Survey information (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm); however, this was used only as preliminary information and does not substitute for a full site geotechnical investigation as required prior to site approval.

Volume of Water Available

A critical requirement of a nuclear generating station is an adequate source of cooling water. The values assigned to the criteria were developed from the EPRI Technical Report: *Water and Sustainability (volume 3): U.S. Water Consumption for Power Production – the Next Half Century.*

The most cost effective cooling system for a nuclear generator is a once-through system. In a once-through system, water is withdrawn from the source, run through the cooling system to draw heat from the reactor and discharged back into the source. 500,000 gallons per minute are required to cool a 1,000 MW nuclear generator utilizing a once-through system. This assumes a water temperature differential of 30 degrees Fahrenheit from withdrawal to discharge. If the receiving water source cannot ecologically absorb that much heat then an alternative cooling source, such as cooling ponds or towers, must be used. The minimum amount of water required for an alternative cooling system for a 1,000

MW facility is 8,000 gpm. Since a nuclear reactor must be constantly cooled, these flow rates must also be constantly available.

Therefore, availability of adequate water supplies was identified as a "fatal flaw" for purposes of site evaluation. Sites with access to water resources with the ability to supply greater than 500,000 gpm scored the highest. Sources without the minimum supply were not further evaluated for nuclear site potential.

Population Considerations

- Exclusion Area Zone

In order for the developer to receive a license to operate a nuclear reactor they must have the ability to establish authority for determining all activities within the vicinity of the facility, including residential restrictions. The licensee must be able to establish the authority to remove all personnel and property within the surrounding area as a safeguard during emergencies. This area is referred to as the exclusion area zone and must be established in accordance with the siting criteria of 10 CFR 100.21(a). The radial distance from the reactor established as the exclusion area zone depends on the reactor power level, allowable containment leak rate, the engineered safety features incorporated into the design, and atmospheric dispersion characteristics of the site.

The evaluation of sites in Kentucky for potential nuclear power stations assumes a safe radial distance from a reactor is 3,000 feet. This distance is based on the calculated radii for water-cooled reactors with power levels ranging from 3 MW up to 500 MW provided in *World Nuclear Power* by Peter R. Mounfield. Based on this study, the median exclusion area distance was found to be approximately 3,000 feet.

Determination of an exclusion zone is based on the expected dispersal rate and direction of radioactive release from the nuclear facility during a major accident.

The boundary of the exclusion zone is established based on the assumption that an individual located at that point would not receive a dose of radiation exceeding 25 roentgen equivalent man (rem). The rem is a unit used to quantify the effective biological damage induced by absorbing a specific amount of radiation. Dispersion models are performed to determine the radial distance from the reactor to avoid receiving a radiation dose in excess of 25 rem.

The exclusion zone is established on the facility design and assumptions about the atmospheric conditions associated with the site. Highway, railroad, and waterway transportation corridors are permitted to traverse the exclusion zone as long as this does not interfere with normal operation of the facility and there is an effective strategy to control traffic.

- Proximity to a Densely Populated Center

Due to the risk of radioactive plumes that could escape a nuclear facility during an accident, the ideal location of a nuclear facility is a rural area with low population density to help minimize human safety, real property, environmental, and economic impacts. Site location in low population areas also facilitates emergency planning and preparedness by the operator and NRC. The NRC recommends that the population density within a 20-mile radius of the site not exceed 500 persons per square mile. The proposed site should also be located away from densely populated centers defined as having 25,000 or more residents within a consolidated area. Therefore, sites with no densely populated center within 50 miles of the site scored the highest.

- Adequacy of Emergency Planning Zones

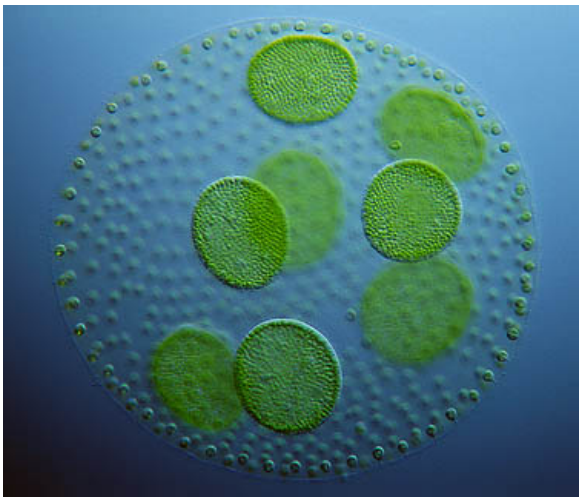
It is critical for operators and emergency coordinators to have an evacuation plan for the area surrounding the nuclear power plant. The ability of residents near a facility to evacuate is influenced by the population density and impediments to egress. According to 10 CFR 100.21(g), "Physical characteristics unique to the

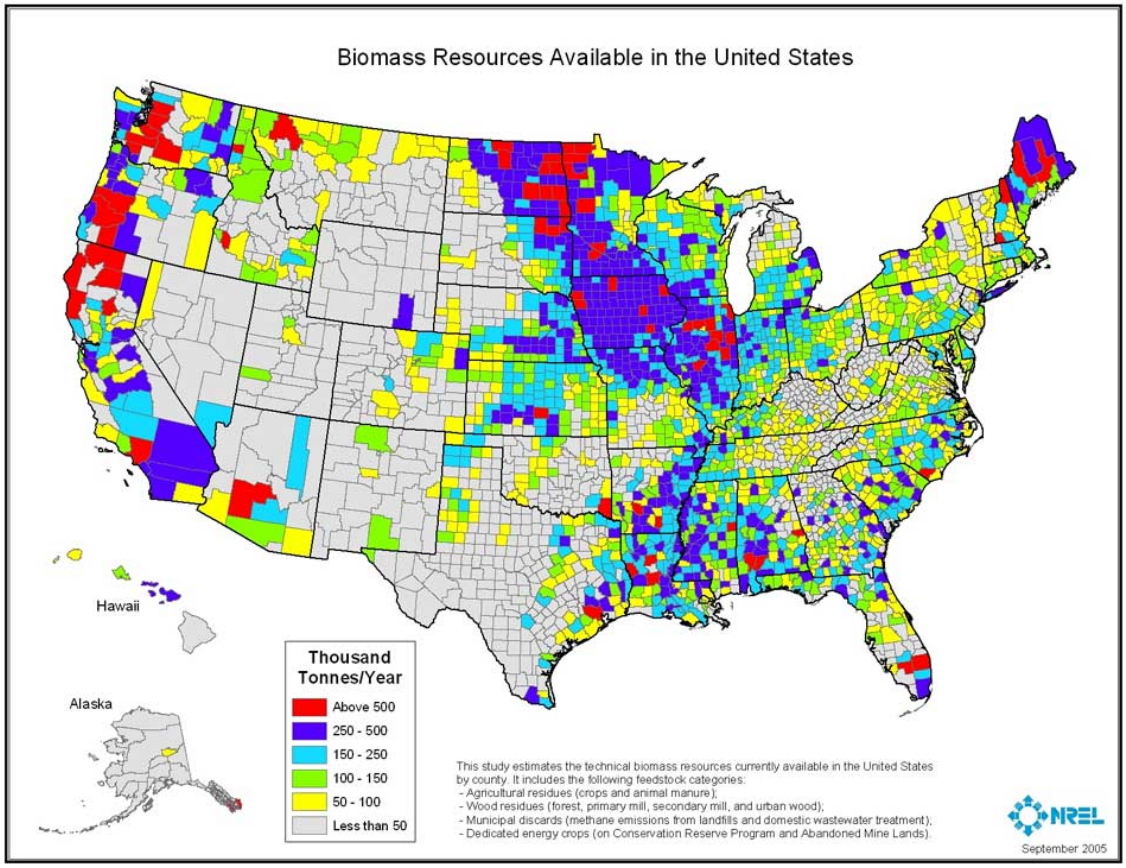
proposed site that could pose a significant impediment to the development of emergency plans must be identified." Impediments to egress include bridges, intersections, on-ramps to major highways, and other potential locations for serious congestion. Egress limitations should be analyzed based on the capacity of roadways (i.e. number of travel lanes) that will support the local population, assuming one car per household. Sites with none of these impediments within 50 miles received the highest score for this criterion.

3.4 Criteria Specific to Biomass

Biomass is organic material such as grains, manure, and grasses that can be utilized as a solid fuel or converted into a liquid or gas to produce electricity, heat, chemicals or biofuels. Common biomass products available on the fuel market today include biodiesel, a derivative of fat and grease, and ethanol, a derivative of corn and sugarcane.

Biomass suffers from low mass, high volume. This means, without a means of condensing or densifying the biomass at the source, transportation becomes a significant cost factor. As a result, biomass resources evaluated were limited to the host county and contiguous counties. If a means of processing the biomass at the source can make transportation and handling of the feedstock less cumbersome, there will be the opportunity to pull from a larger area for a facility's feedstock.





Biomass Resources Available

In order for a biomass facility to be successful and reliable, it needs readily available and proven quantities of biofuel reserves. The National Renewable Energy Laboratory (NREL) has evaluated available types and quantities throughout the United States and the State of Kentucky (Milbrandt, 2005). SMG utilized NREL data to assess the available resources for each site, using NREL County data for the host county and its immediate surrounding counties. The following types of resources available to support and sustain a biomass operation were evaluated:

- Crop residues - corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, dry edible beans, dry edible peas, peanuts, potatoes, safflower, sunflower, sugarcane, and flaxseed;

- Energy crops - switchgrass, miscanthus, willow and poplar;
- Animal waste - diary cows, beef cows, hogs and pigs, sheep, chickens and layers, broilers, and turkey;
- Forest residues – unused portions of trees, cut or killed by logging and left in the woods;
- Primary and secondary mill residues - wood waste (fine and coarse) generated from manufacturing plants and include, slabs, edgings, trimmings, sawdust, veneer clippings and cores, and pulp screenings;
- Urban residues - wood residues from MSW (wood chips and pallets), utility tree trimming and/or private tree companies, and construction and demolition sites;
- Landfill gas – methane generated from municipal solid waste decomposition; and
- Domestic wastewater - methane generated from human waste at municipal treatment plants

Biomass Resources Needed

Various resources were consulted in order to determine what volume of biomass resource would be required in order to operate and sustain a cost effective and successful biomass facility. Individual biomass ranking was based upon these gathered volumes.

Crop Residues

Data obtained from the United States Department of Agriculture (USDA) and the Oak Ridge National Laboratory was evaluated to determine potential energy value of the crop residues available in each county. Data was estimated by using total grain production, crop-to-residue ratio, moisture content, and considerations of the amount of residue left on the field for soil protection, grazing, and other agricultural activities. Typically it takes 7,500 tons of crop residues per year to produce roughly 1MW of power. This

criterion was ranked on a scale of zero to five, with less than 7,500 tons per year being the lowest possible score for crop residue availability and greater than 200,000 tons per year the highest score.

Energy Crops

Energy crops utilized for various biofuels include switchgrass, miscanthus, willow and poplar (Energy Crop Data, 1996). These species are easy to grow, maintain, and harvest in relatively short periods of time at typically lower costs. The amount of energy produced will vary with the nature, size, and type of energy crop utilized. Criterion were ranked with less than 5,000 tons per year earning the lowest possible score for energy crop availability and greater than 200,000 tons per year the highest score.

Animal Waste

SMG reviewed data generated by the USDA National Statistics Service. This data, calculated by animal type and animal waste management system (i.e., lagoons) evaluated methane emissions. It is estimated that 1 MW of power requires approximately 1,600 ton of methane (CH_4) per year at 35% electrical efficiency. Thus, this criterion was ranked on a scale of zero to five, with 1,600 tons per year being the lowest possible score and greater than 7,500 tons per year the highest score.

Forest and Mill Residues

The combustion of wood waste is a common biomass to energy process. The viability of a biomass facility utilizing forest and mill residues may depend on volume and proximity to natural forests, mills, or wood manufacturing operations. Availability was ranked on a scale of zero to five, with less than 5,000 or 7,000 tons per year being the lowest possible score for forest and mill residue availability and greater than 200,000 tons per year the highest score.

Urban Residues

More than likely, urban residues (municipal refuse) would be a supplemental feedstock to an existing biomass facility. Proximity to public access and market areas would have to be considered. Urban residue availability was ranked on a scale of zero to five, with less than 7,000 tons per year being the lowest possible score and greater than 200,000 tons per year the highest score.

Landfill Gas

Methane gas generated from the decomposition of municipal solid waste can be a utilized as a gas for combustion processes or processed as a refuse-derived fuel (RDF). On average it takes about 1.3 tons of municipal solid waste to generate one ton of RDF. Additionally, landfill gas typically contains around 30-55 percent methane and can be combusted to generate electricity (Alternative Energy Solutions, 2007). This criterion was ranked on a scale of zero to five, with less than 1,500 tons per year being the lowest possible score and greater than 7,500 tons per year the highest score for landfill gas availability.

Domestic Wastewater

Like landfill gas and animal waste, methane from waste decomposition along with sludge from wastewater treatment facilities can be converted to fuel. Assuming similar energy generation from landfill gas and animal waste, as stated above, this criterion was ranked on a scale of zero to five, with less than 1,500 tons per year being the lowest possible score for crop residue availability and greater than 7,500 tons per year the highest score.

Although SMG evaluated these types of biomass feedstocks on an individual basis, the individual criteria ranks were weighted low (i.e., a weight of one).

Since many of these feedstocks are not available in abundance in Kentucky, SMG utilized cumulative feedstock availability, summing the various feedstock types with a larger weight. This weight included the volume of materials available at the site location and its surrounding counties. Locations with greater than 500,000 tons per year were considered to have adequate feedstock. Western Kentucky sites provided the largest and most diverse feedstock availability. Thus, these locations typically rated higher for biomass facility location.

Although Western Kentucky sites typically ranked high for biomass availability, development of a biomass facility must take into consideration many factors specific to the type of feedstock utilized. Note that this evaluation did not include an analysis of the potential in the area to grow feedstock specifically for a biomass facility, which should be part of the planning process.

3.5 Criteria Specific to Solar

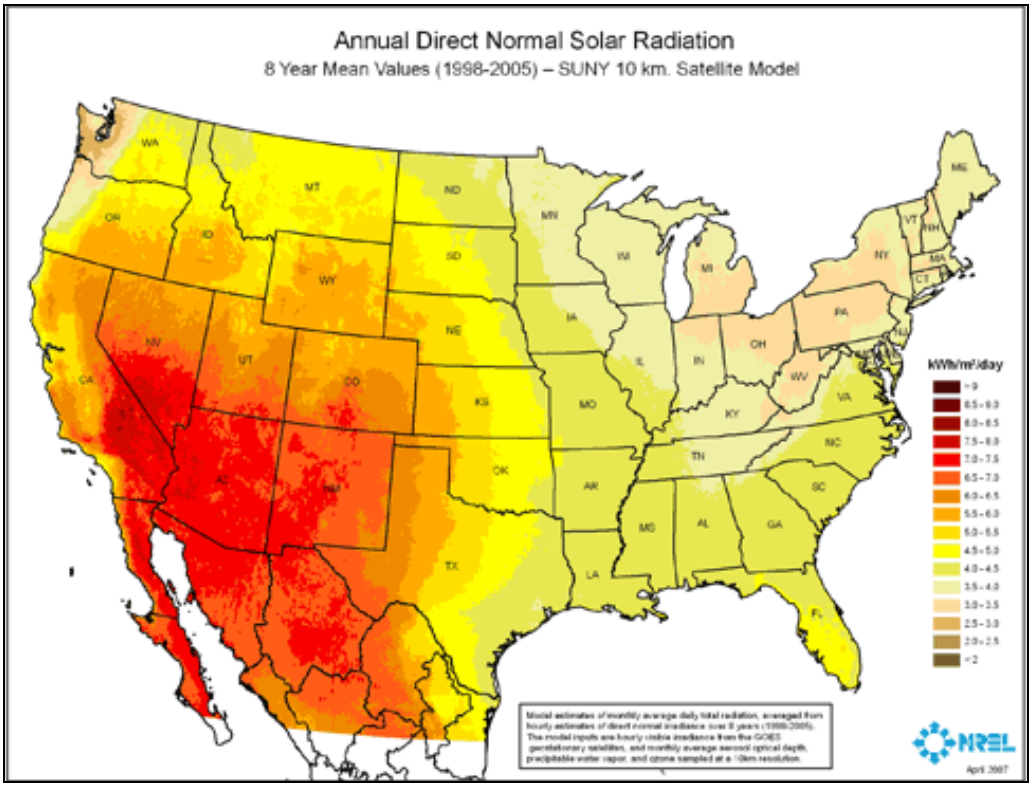
Solar facilities present unique issues for Kentucky. Kentucky does not have a climate or weather patterns that make solar an easy fit. Based on technologies researched and in use today, it is unlikely that a commercial scale solar facility will be economically feasible. Solar, on a distributed basis, can provide support to the electrical demands in our state. However, with the technology available currently, even distributed solar power will likely not provide a return on investment.

Recent testimony by Andy McDonald, Kentucky Solar Partnership, before Kentucky's Environmental Quality Commission, addressed this issue. Mr. McDonald, who is one of Kentucky's most thoughtful and invested solar proponents, stated that a solar installation on a house, designed to provide more than just solar water heating, would cost between $20,000 and $40,000. He indicated that the payback for this system, based on the cost of commercial electricity not used and credit for net metering, would take at least 20 and possibly up to 50 years to realize.

Fortunately, due to the intense focus on renewable power at this time, it is likely that solar technology will evolve at a rapid pace, improving the economic picture associated with solar power in a low solar energy state like Kentucky. As of this date, however, it does not appear that solar power can contribute significantly to Kentucky's energy supply.

Solar Insolation Value

Solar installations were assumed to be, at the minimum, adequate to supply 50kW of power, which is the level that would qualify for incentives under Kentucky HB2. The evaluation of the sites, driven by our recent legislation, is for commercial scale sites, albeit very small ones. There is published data with regard to the solar insolation value required to make a concentrating solar system (CSP) economically viable. NREL studies suggest that CSP systems are not at this time viable in Kentucky as this technology generally requires average solar concentration of at least 6.75 kWh/m2/day in order to be cost effective (Mehos, M. and Owens, B., "Siting Utility-Scale Concentrating Solar Power Projects."). No site evaluated in Kentucky has that level of insolation. Much of the solar energy in Kentucky (and the Southeast US) is diffused by cloud cover and a high concentration of water vapor (humidity).



Two-axis tracking panels can increase the effective insolation value but there is no published data evaluating the parasitic effect of the tracking mechanism and the resulting power and economic impact of these systems to determine a “fatal flaw” number at which this technology is not economical.

Therefore, direct normal solar insolation values were utilized to provide comparison between sites. The two-axis tracking values were also identified for informational purposes.

Site Size

The area and linear dimensions of the proposed site must accommodate a solar collection bank and associated facilities. Size ranges from a minimum of 5 acres for a site producing the minimum 50 kW to sites able to produce the minimum for utility use of greater than 10 MW. The size is established by determining the average solar power per square meter per day. The panel size needed for the type of solar ranges available in Kentucky was calculated and additional acreage was added to address spacing and associated activities.

The criteria considers an electrical output of 1,200 kWh per day (50 kW x 24 hours/day) as the minimum electrical output for the site, matching the minimum output required for HB2 incentive eligibility. PV systems are typically sized to produce the daily demand during the hours that the sun is shining and storing it in batteries.

The minimum size (5 acres) was based on the area required for a PV System with a rated capacity of 400 kW (50 kW x 24hrs/day / 3 solar hours/day). The surface area of PV panels required is approximately 0.75 acres. The additional area is required for panel spacing, controls, and a free zone to prevent any shading of the panels. The area required for 10 MW is approximately 200 acres.

Physical Characteristics

Land cover was considered to assess whether a solar installation would be negatively impacted by surrounding vegetation, structures or land masses. The site should be predominantly free of trees and structures. Atmospheric extremes, i.e. tornados, and seismic risk were considered to factor in potential damage to the facility.

The site's proximity to airports and public access areas was considered as the panels may be a distraction or nuisance if lines of sight are disturbed. Solar sites should avoid low level flight paths for landings and take offs. Areas and resources like parks, wildlife refuges, and recreational areas are used by the public. The public's use of surrounding property and the potential visual impact on their use and enjoyment should be considered in siting any energy facility,

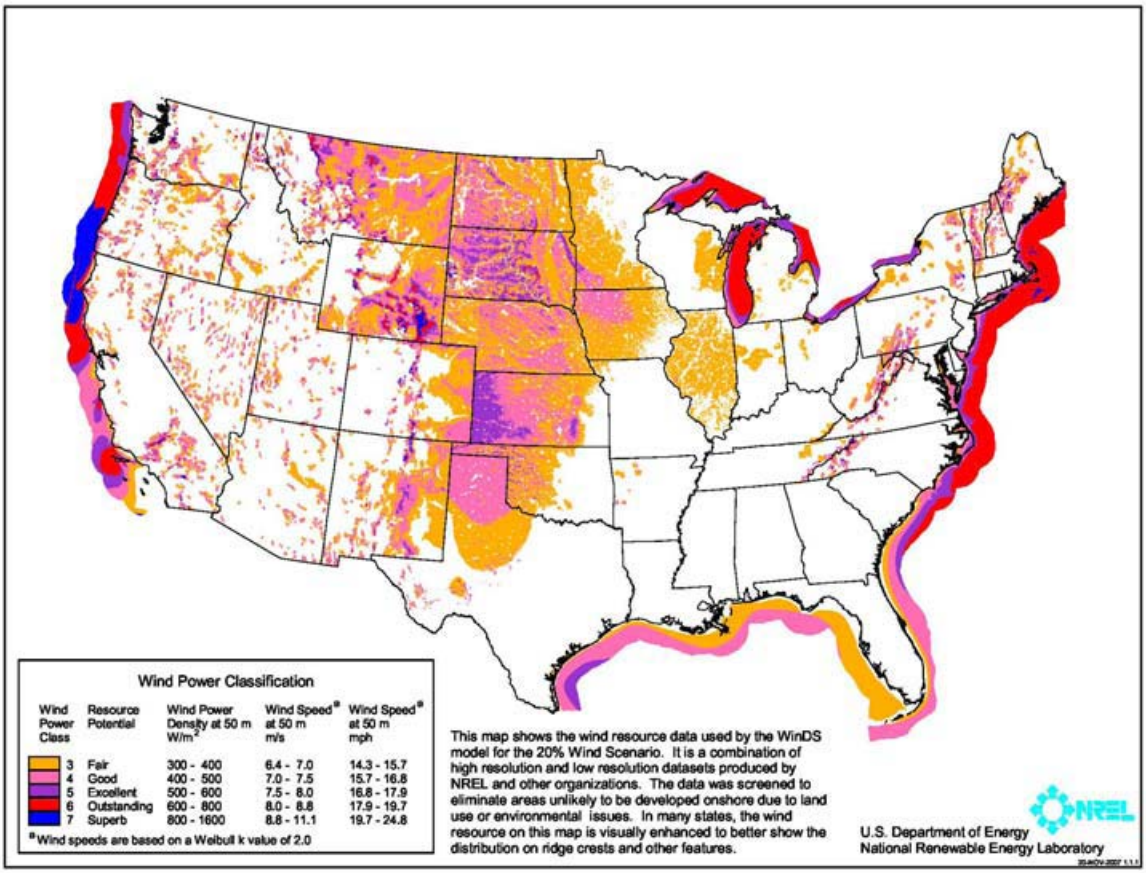
3.6 Criteria Specific to Wind

Wind Speed

Average wind speed is the most important qualifier used to characterize available wind power for each site. Researchers estimate wind speed by using meteorological data (e.g. atmospheric models and satellite observations), local topography, temperatures and surface conditions to create computer-generated maps. NREL researchers have compiled the available data in a high resolution map which provides wind speed values for 200 meter square areas across the nation. According to the AWS Truewind website, the standard error of the high-resolution maps for the lower 48 states is 0.75 meters per second. Data from this high resolution map are averaged over 2.5 kilometer square areas around each point to create the lower resolution map which is available to the public as part of the windNavigator® tool. The readings generated by this tool were confirmed with wind resource mapping available from NREL GIS data.

Values used for the Site Bank analysis were taken from the publically available data found in the windNavigator® tool, generating the annual average speed. Wind speed values were evaluated at a projected hub height of 60 meters (approximately 200 feet). Hub height is the distance from the ground to the centerline of the turbine rotor. Extrapolated data is also available for hub heights of 80 meters (approximately 260 feet) and 100 meters (approximately 325 feet). Hub height of 60 meters was selected for evaluation because most research identifying minimum wind speed required to provide efficient and effective wind

power is based on hub heights of 50 meters. The 60 meter scale in the AWS Truewind utility is closest to the research benchmark. While wind speeds generally increase at the higher hub heights, the cost of construction of taller and more substantial wind turbines increases dramatically. These costs reflect the more substantial engineering and foundation required to prevent collapse or overturning of a larger, heavier structure, as well as the increased costs of the larger structure itself.



Research indicates that utility scale wind can be successful with Class 4 and greater average wind speeds. Based on research and data gathered from NREL and other listed resources, a site should have an average wind speed of 5.6 meters per second in order to adequately support a commercial power generation facility. Locations with annual average wind speeds less than 5.6

meters per second are not considered economically feasible for development of commercial power generation facilities. Because this is the critical factor for wind power, site evaluation was discontinued if the mean annual wind speed was less than 5.6 meters per second. The majority of the land in Kentucky has mean annual wind speeds less than 5.6 meters per second.

NREL - Classes of wind power density at 10 m and 50 m(a) **www.nrel.gov/gis/wind.html**				
Wind Power Class	**10 m (33 ft)**		**50 m (164 ft)**	
	Wind Power Density (W/m 2)	**Speed (b) m/s (mph)**	**Wind Power Density (W/m 2)**	**Speed (b) m/s (mph)**
1	0	0	0	
2	100	4.4 (9.8)	200	5.6 (12.5)
3	150	5.1 (11.5)	300	6.4 (14.3)
4	200	5.6 (12.5)	400	7.0 (15.7)
5	250	6.0 (13.4)	500	7.5 (16.8)
6	300	6.4 (14.3)	600	8.0 (17.9)
7	400	7.0 (15.7)	800	8.8 (19.7)
	1000	9.4 (21.1)	2000	11.9 (26.6)

a. Vertical extrapolation of wind speed based on the 1/7 power law.
b. Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density. Wind speed is for standard sea-level conditions. To maintain the same power density, speed increases 3%/1000 m (5%/5000 ft) elevation.

*NOTE: Each wind power class should span two power densities. For example, Wind Power Class = 3 represents the Wind Power Density range between 150 W/m^2 and 200 W/m^2. The offset cells in the first column attempt to illustrate this concept.

The preceding chart illustrates the classes of wind speed identified by NREL. Note that Class 4 wind speed at 50 meters hub height ranges from 7.0 m/s to 7.5 m/s. Based on wind speed mapping by NREL, Kentucky's best sites have wind speeds at this hub height only at the lower end of Class 2, ranging around 5.6 m/s.

A map of annual wind power at 50 meters created by NREL is included in **Appendix E** to this report. The map indicates that the entire state of Kentucky is ranked as poor with annual average wind speed at less than 5.7 m/s at 50 meters in height. This map was created utilizing AWS Truewind Mesomap system and historical weather data and validated with available surface data.

Seismic Stability and Foundation

Soil stability is an important factor because wind turbines are mounted on tall (200-350 feet), stationary tower structures. The turbines will be subject to natural stresses from blade rotation, seismic activity and tornado/storm activity. Construction of towers will likely involve drilling into the bedrock.

Visual Impact and Aviation Compatibility

Wind turbines are large structures that can be a nuisance or eye sore to some residents or have a visually adverse effect on the landscape. Visibility of wind turbines is highly dependent on topography, ambient weather and sky conditions. Total height of a tower with rotor blades from ground level to the highest point of the blade tips has increased from 100 feet to between 330 and 460 feet. To reduce visibility, turbines are usually painted white or off-white. While economics is the deciding factor for wind turbine size and layout, it is more desirable for a smaller wind facility to be placed in close proximity to residential areas as opposed to a larger facility.

Preferable location for a wind farm is away from tourist landmarks, historic properties, scenic and residential areas. Wind farms appear to be more aesthetically compatible with land already used for agricultural purposes.

The Federal Aviation Administration (FAA) is responsible for regulating the construction of structures taller than 200 feet (14 CFR Part 77). Wind turbines are generally taller than 200 feet and could present flight hazards if an airport is in close proximity. For this reason, it is desirable to have the site at least five miles from any airports. FAA lighting is required on all wind turbine structures and the regulations are similar to other tall structures, like cell and radio towers.

Telecommunications Interference and Military Sites

Similar to other large structures, wind turbines have the capacity to interfere with radio frequency signals by deflecting the signal. The turbine blades, as the moving component, can also contribute to interference. The current generation of turbine blade technology has less potential to interfere with radio transmissions because most blades are now made from plastics and composites, as opposed to steel. Services that are vulnerable to communication distortion include microwave systems, off-air tv broadcast signals (analog only), land mobile radio, long range military radar, mobile phone services, and AM/FM broadcast signals.

The following FAA link connects to the Department of Defense (DoD) Preliminary Screening Tool which provides mapping of the location of the sites in relation to range of Air Defense and Homeland Security radars. Regardless of the map output, an aeronautical study will be required prior to construction of wind turbines determine type and level of interference. *https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showLongRangeRadarToolForm*

Bird and Bats Impacts

The vibration from the rotation of the turbine blades may have a negative impact on the sonar-navigating ability of local bats species. The potential to negatively impact migratory bird species exists because wind turbines are large structures that may interfere with flyways. Unlike cell towers, wind turbines have the added risk of large moving parts. The National Wind Coordinating Committee (NWCC) completed a comparison of wind farm avian mortality with bird mortality caused by other man-made structures in the U.S. The report concluded that commercial wind turbines cause the direct deaths of only 0.01% to 0.02% of all of the birds killed by collisions with man-made structures and activities in the U.S. Despite these findings, flyway routes and possible impact to local or transitory bird and bat species should be analyzed prior to turbine construction.

Public Health and Safety Issues

The following issues drive a need to carefully site wind turbines where they will not pose a safety risk to the public or site workers.

- Blade Drop and Throw

A mechanical failure or equipment malfunction can result in blades falling off the turbines or being thrown up to half a mile away. Certainly not a common occurrence, it could happen during a large storm.

- Shadow Flicker

Depending on site terrain and latitude, wind turbine blades can create long shadows when the sun is behind them. These shadows “flicker” like a strobe on the walls inside homes close to the turbines. In some instances, the shadows may cause dizziness, migraines or nausea to people prone to motion sickness or car sickness. This occurs because the three organs of position perception (the inner ear, eyes, and stretch receptors in muscles and joints) are not agreeing

with each other: the eyes say there is movement, while the ears and stretch receptors do not.

- Noise

Noise from air-to-blade contact and rotor revolution can disturb residents within 2 miles of the turbines. In addition to being bothersome, repetitive low frequency noise can cause anxiety and disrupt sleep activity.

- Ice Shedding

Ice build-up on blades is a risk for wind facilities during wintry conditions. Ice shedding occurs as temperatures rise and ice thaws from the rotor. Build up of ice on the rotor and wind sensor can cause sensor meltdown and result in turbine shutdown. Ice falling from the blades will be thrown if the blades are in motion. Operational staff is more likely to be at risk.

4.0 SITE EVALUATIONS

Forty of the original forty-one sites have been evaluated for their potential for wind, solar, bio-mass and nuclear facilities. A narrative report has been created for each site which describes the site and its suitability for all five of the energy technologies reviewed. The criteria also produced a score for each site, for each technology. This enables us to see which sites appear to be best suited for each technology.

CTL/CTG

CTL/CTG criteria have been used previously with these 40 sites, and the results are not new or surprising. Of the 40 sites, thirteen scored above 85% of the maximum possible score. Four scored above 90%. The top CTL/CTG sites are:

- D.B. Wilson Power Generating Plant in Ohio County with a score of 93%,
- Ashland Coal Dock and the adjacent property in Boyd County also with a score of 93%,
- J.K. Smith Power Station in Clark County with a score of 91%, and
- The former Martiki mine site in Martin County with a score of 90%.

The D.B. Wilson site is adjacent to another large tract of land referred to in this Report as the Ohio County property, which independently scored 87% for CTL/CTG. The combination of these properties would create a potential development site of over 3,500 acres.

Biomass

Biomass energy facilities have much in common with CTL/CTG facilities. They demand a large area to cope with material handling issues and will require only slightly less water. The top four biomass facilities are:

- D.B. Wilson Power Generating Plant in Ohio County with a score of 90%,
- Penn Virginia Areas A and B in Henderson County with scores of 85% and 83% respectively, and

- Henderson Riverport in Henderson with a score of 80%.

The Penn Virginia properties, when combined with Area C (which scored 75%), would offer a combined development area of over 2,600 acres. Additionally, these properties are immediately adjacent to the Cash Creek project which has currently obtained most of the required permits for a Coal to Syngas facility that will also have a co-located generating plant. The development of the adjacent property will bring much needed infrastructure to the property, making the Penn Virginia property even more attractive. The Henderson Riverport has the smallest amount of available acreage, but its transportation options are excellent, potentially allowing a facility to use off-site feedstock preparation and handling.

Nuclear

Nuclear facilities require vast amounts of water and should not be sited in highly populated areas. Of the 40 sites evaluated, 15 did not have adequate water to meet the minimum required. The top ranked sites are the only three that scored above 75% of the maximum possible score for a nuclear facility. The top sites are:

- D.B. Wilson Power Generating Plant in Ohio County with a score of 87%,
- The Dover site located in Mason County with a score of 81%, and
- The Skillman Bottom site located in Hancock County, with a score of 79%.

The Dover and Skillman sites are located on the Ohio River and the Wilson site is on the Green River. The Dover site has the closest population cluster of the three sites, the small community of Dover, Kentucky. The next highest scoring sites were the Penn Virginia complex and the property adjacent to D.B. Wilson.

Wind

Evaluation of the potential for commercially feasible wind facilities proved to be an exercise in futility. Based on the technology available now, research indicates that Kentucky does not have adequate wind speed to support an economically viable commercial facility. No site was found to pass the “fatal flaw” test of an

average wind value of 5.6 meters per second. This result does not mean wind should be ruled out of the renewable energy picture. Rather, site specific research should be conducted in those areas which are projected to provide the best likelihood. Wind data available for preliminary evaluations, like this report, are often extrapolated from surrounding areas and weather data. In addition, wind may provide supplemental power on a distributed basis, helping the individual property owner with power needs and supplying power back to the transmission grid. Of course, this must be done safely and within the Net Metering and Interconnection Guidelines of the Public Service Commission (PSC).

Solar

Solar technology suffered much the same fate as wind, although no "fatal flaw" test was appropriate with solar generation. Kentucky's solar insolation is below that which has been identified as viable for a commercial-scale facility. Solar can, however, play a part in Kentucky's renewable energy supply. Solar power efficiency and cost viability is impacted by low solar insolation values, caused by a high number of cloudy or hazy days and the fairly high cost of solar collector equipment and installation. While the raw solar power available in Kentucky is not expected to change, the equipment's efficiency is expected to increase and the costs drop, bringing distributed power into the mix. Currently, with the exception of small and not critical uses like water heating, the use of solar power in this state continues to be too expensive and intermittent to add measurably to support base load generation. Just as with wind, solar is expected to provide supplemental power on a distributed basis, potentially reducing the local draw on base load and supplying power back to the transmission grid, when available and to the extent it can be safe and within the guidelines established for net metering.

SITE COMPARISON
FINAL-SITE REPORTS
ALTERNATIVE ENERGY SITE BANK EVALUATION
PON 2 127 0800010168 1
DEDI
JUNE 2009

Site Name	Acres	County	Score (%)				
			Biomass	Nuclear	Wind	CTL/CTG	Solar
Airport Pike Co	633	Pike	62	0	0	61	42
American Electric Power - Henderson	4,700	Henderson	65	58	0	60	32
Area A Penn Virginia	1,005	Henderson	**85**	73	0	86	58
Area B Penn Virginia	1,130	Henderson	**83**	72	0	84	58
Area C Penn Virginia	530	Henderson	75	65	0	80	58
Ashland Coal Dock	385	Boyd	78	63	0	**93**	63
Bailey Port - Marshall Co	650	Marshall	76	55	0	82	55
Big Rivers Ohio	1,246	Ohio	76	71	0	87	55
Big Shoal - Pike Co	215	Pike	70	56	0	86	50
Brier Creek - KenAmerican Coal	700	Muhlenberg	67	0	0	64	64
CH Development - Corbin	776	Knox	79	0	0	87	64
Chisolm Mine, Phelps	562	Pike	70	0	0	69	58
Clay County Industrial Park	1,000	Clay	65	0	0	69	58
D.B. Wilson Power Station	2,300	Ohio	**90**	**87**	0	**93**	68
Dover Kentucky Industrial Site	938	Mason	69	**81**	0	75	33
Hancock County - Lewisport	1,108	Hancock	70	56	0	69	47
Hancock County - Skillman Bottom	1,020	Hancock	63	**79**	0	86	59
Henderson Riverport	230	Henderson	**81**	67	0	88	60
Highway 205 - Morgan Co	450	Morgan	56	0	0	53	45
Hopkins Branch - Pike Co	216	Pike	74	60	0	75	48
Hopkins County - Alliance	11,500	Hopkins	73	0	0	81	57
J.K. Smith Power Station	3,200	Clark	75	0	0	**91**	61
Knott County Industrial Park	760	Knott	55	0	0	56	54
Lexington Coal - Martiki Mine Martin Co	5,000	Martin	75	68	0	**90**	66
Marion Branch - Pike Co	450	Pike	69	68	0	83	66
Marshall County Industrial Park - Calvert City	736	Marshall	75	59	0	80	50
Maysville	380	Mason	72	65	0	84	55
Paradise Mine - KenAmerican Coal	650	Muhlenberg	66	51	0	66	52
Pine Branch Coal Company	4,000	Perry/Breathitt	76	0	0	71	57
Pine Mountain Regional Industrial Park	500	Bell	69	63	0	81	41
Purchase Regional Industrial Park	2,000	Graves	66	0	0	69	39
Reid-Green Power Station (Big Rivers)	1,149	Webster	79	65	0	89	59
River View Coal - Alliance	600	Union	78	58	0	84	61
South Shore - Greenup County	500	Greenup	78	62	0	86	57
Steamport, Allied Resources	500	Webster	80	64	0	89	64
SWEDA	325	Washington	60	0	0	59	47
Teco Coal - Perry County Coal - Hazard	700	Perry	74	0	0	85	60
Teco Coal - Premier Elkhorn, Myra	500	Pike	69	0	0	69	67
TVA Hickman Property	841	Fulton	75	51	0	80	46
Webster County - Alliance	2,500	Webster	80	0	0	76	62

Notes:

1. *0 denotes fatal flaw existed for site

Energy Farms?

A comparative score sheet with the score achieved by each site for each technology has also been compiled and review of that sheet is instructive. The comparative sheet helps us identify which sites may be appropriate for an "Energy Farm", a facility which supports more than one energy technology. Several facilities appear to be likely to succeed with multiple energy technology facilities. The following is a brief listing of those facilities that, through high scores in more than one category, and substantial site size available for development, may provide good opportunity for energy farm development. This list is not exclusive and is intended to illustrate the energy farm concent.

The D.B. Wilson plant currently operates a coal-fired generating plant on a property described as containing 2,300 acres. Locating a gasification, biomass or nuclear site at this site would likely be successful. The site has been developed to support at least two generating plants, however, only one is constructed. There is a well developed barge facility and, as an electrical generating facility, transmission is at the site. A full connectivity and transmission capability study would have to be conducted to determine the capacity for additional transmission from the site, but right of way and infrastructure for large transmission is already located at the site. A second large property is located immediately south of the facility which would allow adequate room for any configuration of energy facilities. The combined site would include over 3,500 acres.

A second likely possibility is the Penn Virginia complex, especially with the ongoing development of the Cash Creek project on property immediately to the south. This mega site of 2,600 acres, is located on the Green River, which has adequate water supply and forms a major water transportation route. The

adjacent development will bring substantial transmission capacity to the site, presumably for both electricity and for syngas. Coal supplies are mined on the property, with several other suppliers nearby. Western Kentucky appears to have an abundance of biomass available within a reasonable distance.

Marshall County offers two sites, both greater than 600 acres, which, while not ranking at the very top of any list, provide good opportunities for multiple technology development and a market for energy or chemical products within the Calvert City industrial community. The Hancock County Skillman site, with over 1,000 acres available for development, ranked well comparatively for nuclear generation and has excellent ranking for CTL/CTG with a score of 86%.

Henderson Riverport also scores well in more than one category, although its size of 230 acres presents a limitation. Although the proximity of the Henderson County airport will limit certain aspects of development, its location and transportation assets are key. The potential for additional property which may become available to the Riverport could enable this site to be a successful project.

The former Martiki mine site in Martin County has scored near the top for CTL/CTG and has a healthy biomass score, making it a likely area for development of an energy farm in eastern Kentucky. This property ranks as one of the largest in the Site Bank with over 5,000 acres available for development.

The individual site reports, together with the Energy Projects Site Bank website, provide extensive information and give potential developers the ability to evaluate the sites by size, location and suitability for each technology.

5.0 WEB SITE

The web site that was created with the first set of CTL/CTG site evaluations has been revised and restructured to include information about each site's potential for each of the reviewed technologies. Additionally, we have restructured the site to allow the user to search based on location, size and suitability. The site is built on a Cold Fusion platform and all web files are delivered electronically for migration to the state's system.

The site can be viewed currently by going to www.emcilink.com/sitebank

6.0 GIS STUDY

As a part of this project, Sanborn, in conjunction with RE Strategies, prepared an analysis of the 40 sites, utilizing the mapping and datasets used to complete the Renewable Energy Resources Inventory in Kentucky which was submitted to DEDI in June 2008. In the 2008 report, exclusionary and inclusionary criteria were used to determine if previously mined sites could be identified which would have certain suitability factors for biomass, solar and wind facilities. In conjunction with the current project, Sanborn applied the same approach, co-locating the 40 identified sites with their original criteria to determine if any would be cross referenced. The Sanborn/RE Strategies Report is included as **Appendix F** to this report. The results of the Sanborn mapping and GIS research are interesting and indicate that this approach can be a useful tool.

Wind

The Sanborn research recognized that the two basic regions of Kentucky should be evaluated differently for wind, based on the very different topography found in each. A summary table describing the wind criteria used and the differential between the two regions evaluated is located on pages 6-7 of the Sanborn Report. However, because the criteria used to identify suitable locations for wind facilities did not factor in available wind data, the conclusions in that report must be further researched to reach a conclusion.

The Sanborn report identified five sites as their top ranked sites for wind generation, based on the criteria described in the report. Four are eastern Kentucky sites: Clay County Industrial Park, Premier Elkhorn in Pike County, Pine Mountain Regional Industrial Park in Bell County and Knott County Industrial Park. These sites have benefited from elevation and their status as former mine sites, resulting in little blocking vegetation or land masses.

Solar

Solar criteria used for the Sanborn analysis utilized factors appropriate for Concentrating Solar Power technology. Those criteria are described on pages 16-18 of the report. Both sections of the state were analyzed for solar utilizing the same criteria. The solar criteria excluded direct normal solar insolation values of less than 3.0 kWm/m2/day. SMG's research indicates that in order to be economically viable as a commercial facility, the solar insolation value should be at least 6.75 kWm/m2/day. The lower values may well provide solar power on a less economically strong model and could be beneficial for distributed power generation. However, no research found supports the economic viability of this level of insolation at this time. The Sanborn report acknowledges this stating on page 17, "Kentucky's solar resources are below the threshold used for the WGA analysis of Western States. Developing CSP in Kentucky will require changes in technology, economics or policy that enable CSP to be developed in areas with our solar radiation levels".

7.0 LESSONS LEARNED/ NEXT STEPS

Our primary lesson is that Kentucky has sites that are ready for energy project development. At this time, our best likelihood of commercial success, based on siting criteria, is for CTL/CTG, biomass and nuclear. Kentucky has vast fossil fuel resources and substantial biomass resources and the ability to find and create more resources to fuel a biomass industry, we are not rich in solar insolation or wind speed. We currently have a nuclear industry located within our state boundaries, one which has served the nuclear power industry for decades. We have several sites within Kentucky that would provide a suitable location for nuclear power generation, should our State determine it wants to move in that direction.

Certain areas for additional research or development have become obvious in the process of the Site Bank evaluations.

- **Transmission capacity and flexibility** will be a key to successful development of additional base load or distributed power generation. Currently, the transmission grid has areas which limit development, and few areas where power flow is as flexible as it will need to be to be able to utilize and manage intermittent power flow from some of the renewable technologies that will eventually develop.
- Energy project developers need **regulatory assistance and certainty**, both on the state and on the federal level. A clear regulatory and permitting road map should be developed for biomass, nuclear, solar and wind projects. Although the State cannot control the federal permitting process, it can live up to the mandate of providing a coordinated permitting approach for energy project developers. The Site Bank II project resulted in a permit map which outlines the regulatory path to development of CTL/CTG projects. A similar approach can be taken for other energy developments.

- Kentucky must continue its strong support of **research in all forms of energy development and carbon sequestration**. Research to understand and quantify the carbon sequestration potential for the state should continue and expand and should include geologic sequestration, terrestrial sequestration and the legal issues raised by both. Regardless of all other efforts towards efficiency, renewables or nuclear, coal will continue to be our major energy feedstock for several decades. With expected carbon constraints, our state will lose the ability to maintain its industry, workforce and portions of its population unless we can address the Carbon question efficiently and reasonably.
- Kentucky must find a way to continue its support of **energy projects moving towards commercialization**. The approach taken over the past few years of partnering with energy developers by providing grants is an effective way to make Kentucky's research and economic development dollars go further.
- Siting, permitting and regulatory issues must be identified and solved to enable **CO2 pipelines** to move large quantities of CO2 to a reuse facility or sequestration location.
- Thoughtful and serious discussion about the **benefits and limitations of nuclear power** must occur. If we are not going to use nuclear power, our efforts to develop clean coal, CTL/CTG, carbon capture and sequestration must be increased dramatically, as that is our most abundant resource.
- A Kentucky specific **economic analysis of the potential for success in wind and solar power**, and the impact we may see through distributed generation, should be conducted. Distributed power generation from solar and wind may help supply some of the growing demand if we can solve the access and cost issues inherent in these renewable technologies. Until we can demonstrate that an individual or company that invests in solar or wind generation in Kentucky can realize a return on their investment, there will be no wide-spread development of this resource.

Siting criteria developed for the Site Bank project cannot evaluate the economic aspects of a proposed facility. Information available currently is based on other areas of the country and is not specifically suited to Kentucky's environment.

Now, the state needs to tackle the large issues and find ways to enable base load power to meet our growing needs while dramatically reducing our carbon emissions, as we will soon be required to do. To meet the goals outlined in the Energy Strategy, each of the development areas described above will have to be addressed to some extent. Each will require governmental and policy engagement at a high level. Each of these areas has been reflected, in some way, in the national debate over energy and climate change. All can be tackled by taking steps to solve the road blocks and answer the questions.