II. ALTERNATIVES TO PROPOSED ACTION (BBNPP ER 9.0)

Section II explores the alternatives to the proposed siting and construction of a new nuclear plant at the BBNPP site. Included in the alternatives assessment is a “no-action” alternative, alternatives that don’t require any new generating capacity, and alternatives that do require new generating capacity, but from sources other than nuclear.

NO-ACTION ALTERNATIVE (BBNPP ER 9.1)

The "No-Action" alternative refers to a scenario where a new nuclear power plant is not constructed and no other generating station, either nuclear or non-nuclear, is constructed and operated.

The most significant effect of the No-Action alternative would be loss of the potential 1,600 MW additional generating capacity that BBNPP would provide, which could lead to a reduced ability of existing power suppliers to maintain reserve margins and supply lower cost power to customers. Under the No-Action alternative, this increased need for power would have to be met by means that involve no new generating capacity.

Under the No-Action alternative, PPL would not be able to satisfy corporate climate change policy objectives that include reducing greenhouse gas emissions while maintaining a strong economy, reducing dependence on foreign energy sources, and providing reliable electricity supply and infrastructure .

Although Pennsylvania has not, at this time, established mandatory programs to regulate carbon dioxide and other greenhouse gases, it is observing though not participating in the Regional Greenhouse Gas Initiative (RGGI), a cap and trade program among nine northeastern states. As of November 2007, three other states within the Region of Interest (ROI)/primary market area (New Jersey, Delaware, and Maryland) are members of RGGI (MDE, 2008).

PPL Corporation has conducted an inventory of its carbon dioxide emissions and is continuing to evaluate various options for reducing, avoiding, offsetting, or sequestering its carbon dioxide emissions. PPL Corporation believes that the regulation of greenhouse gas emissions may have a material impact on its capital expenditures and operations, but the costs are not now determinable.

The No-Action alternative is not optimal from the standpoint of the cost of operation or the cost of supplied power. Generating capability within this ROI/primary market area could become increasingly dependent on existing fossil fuel generation. If current trends continue, it is expected that older steam units in the east will be replaced by units burning natural gas (PJM, 2008b).

Without additional nuclear capacity, the ROI/primary market area would not recognize the role that diversity of generation fuels has in satisfying the overall reliability needs of the PJM Regional Transmission Organization (RTO) power system. For example, the development and installation of many gas-fired plants and recent shortages in gas supply and pipeline capability in some areas of the RTO have highlighted this issue. If PPL took No-Action to meet growth demands, the ability to supply low-cost, reliable power to its customers and to the RTO would be impaired. In addition, PPL would not be able to support national goals, as established in the Energy Policy Act (EPACT) of 2005, to advance the use of nuclear energy.

The following points suggest the continuing benefits of and the need for a new merchant baseload generating facility in the ROI/primary market area:

- the region's need to diversify sources of energy,
- the potential to reduce the average cost of electricity to consumers, and
- the current national policy to reduce dependence on fossil fuels.

The BBNPP would provide much needed baseload power (i.e., the quantity of generation that exists continuously during a given period) for the ROI/primary market area that is expected to have average annual peak forecast growth between 1.2% (winter) and 1.6% (summer) per year over the next 10 years (PJM, 2008a). The BBNPP will help meet the growing demand for new capacity and reduce carbon emissions in the ROI/primary market area. Implementation of the No-Action alternative could result in the future need for other generating sources, including continued reliance on carbon intensive fuels, such as coal and natural gas. Additional benefits of the construction and operation of the BBNNP include positive economic and tax impacts to the surrounding region.

Under the No-Action alternative, the predicted construction- and operation-related impacts from the project would not occur at the site. Those impacts would result primarily from the construction of the facility and would include land use, ecological, socioeconomic, and water-related impacts. The potential adverse impacts identified from the *operation* of BBNPP are anticipated to be small for all categories evaluated. ("Small" is defined by the NRC as follows: Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource (NRC, 2001).)

ENERGY ALTERNATIVES (BBNPP ER 9.2)

This section discusses two broad categories of alternatives to a new nuclear plant at the BBNPP site:

- Alternatives not requiring new generating capacity
- Alternatives that require new generating capacity

Some of the alternatives described and discussed below were eliminated from further consideration based on their availability in the region, overall feasibility, and environmental consequences. The alternatives that were not eliminated are assessed in greater detail relative to specific criteria such as environmental impacts, reliability, and economic costs.

Alternatives Not Requiring New Generating Capacity (BBNPP ER 9.2.1)

Initiating Conservation Measures (BBNPP ER 9.2.1.1)

Historically, state regulatory bodies have required utilities to institute programs designed to reduce demand for electricity. Demand-side management (DSM) has shown great potential in reducing peak-load consumption. DSM programs consist of planning, implementing, and monitoring activities of electric utilities to encourage consumers to modify their level and pattern of electricity usage. According to the Department of Energy/Energy Information Administration, in 2006, peak load usage was reduced by 27,240 MW through DSM strategies. This reduction is 6% greater than that of the 25,710 MW reduction in 2005 (EIA, 2007a). However, DSM costs increased by 6.8% over the same period (EIA, 2007b). Although DSM has shown great potential in reducing peak load usage, it cannot reasonably be expected to displace the need for the 1,600 MW of baseload power that would be provided by BBNPP.

Conservation Programs (BBNPP ER 9.2.1.1.1)

Conservation programs are generally comprehensive and complementary and focus on providing technical and financial assistance to homeowners, businesses, schools, and government organizations.

Pennsylvania has implemented the Alternative Energy Portfolio Standards (AEPS) Act that includes provisions for market-based DSM measures to reduce electricity demand within the commonwealth. Prior to implementing the AEPS Act, Pennsylvania had developed, through individual settlements with the commonwealth's major distribution companies, a comprehensive program to promote and advance DSM in the retail electric market. The Pennsylvania Sustainable Energy Board (PSEB) worked in partnership with regional sustainable energy boards, other Commonwealth agencies, electric utilities, business organizations, and environmental organizations to develop and implement "tools" to save energy. Five settlement agreements were established as separate and independent sustainable energy funds to promote: (1) the development and use of renewable energy and clean energy technologies, (2) energy conservation and energy efficiency, (3) renewable energy business initiatives, and (4) projects that improve the environment in the companies' service territories, related to the transmission and distribution facilities. PPL Electric Utilities Corporation (PPL EU) DSM offerings under this program included energy efficiency programs, education programs, renewable energy projects, and clean energy projects (PSEB, 2004). It is expected that projected energy efficiencies would be anticipated by the market.

PPL EU is an industry leader in establishing programs to help customers save energy, promote energy efficiency, and understand how they can reduce their electricity use and cost. PPL EU has offered customer electric use DSM and financial assistance programs for a quarter of a century, and PPL EU plans to continue to increase the number of and financial support for these programs. In the past, PPL EU offered large industrial customers a DSM program that allowed them to curtail their electric load during heavy system peak use. The companies were financially rewarded with a lower price per kilowatt hour (kWh) for allowing PPL EU this control over their demand. PPL EU also has had a pilot DSM program for residential customers for the last six years. That program is focused on on-peak and off-peak time-of-use rates in trying to get customers to reduce demand and their cost during these peak energy use times on weekdays. As the energy landscape is changing, PPL EU is developing more programs and tools to help customers understand how they use energy, and learn what they can do to save energy and money on their bills.

The following provides additional information on these and other customer energy savings programs:

- Customer Daily Electricity Use: In 2004, PPL EU completed installation of automated meters for all its customers, making it one of the first electric utilities in the country to install advanced electric meters that can be read automatically by the company, saving the energy previously required from manual reading operations. PPL EU can use the capability of these advanced electric meters to provide customers with their monthly and daily energy usage and show customers trends in their monthly electricity use on their bills. By 2009, customers will be able to see their hourly electricity use. All this information will enable customers to evaluate the effectiveness of their energy efficiency actions, and make even more informed decisions about their electricity use.
- Expansion of Existing Pilot Program: Since 2002, PPL EU has operated a residential customer pilot program for time-of-use electricity pricing during the summer months. Approximately 300 residential customers currently participate in the program. PPL EU is expanding the program in 2008. The expanded program will provide about 600 participating customers an opportunity to lower their bills by conserving energy during "on peak" hours, when the cost of wholesale electric generation supply is greatest. The participants in the expanded pilot program will be able to track their hourly electric use using the company's Energy Analyzer. In addition, the company is planning a year round time of use pilot program that could begin in late 2008.
- Energy Analyzer Website: In June 2007, PPL EU launched a new website with an online Energy Analyzer tool that helps customers understand and manage their electricity use, and identify actions they can take to use energy wisely. The Energy Analyzer had more than 165,000 individual users in its first nine months.
- The website's Energy Analyzer tools offer customers the ability to see detailed electricity use information, understand where their homes use energy, and compare their energy use with that of similar homes. Customers can also create personalized home energy use reports by using the Energy Analyzer. They can use the site to

calculate how much energy they use for heating, cooling, lighting, refrigeration, and other appliances, and identify no-cost and low-cost measures to save energy. They can also learn how much energy they can save by replacing existing equipment and appliances in their home with more energy efficient models.

- The website includes an Energy Learning Center where a customer can calculate the energy use of various appliances and learn about potential savings by switching to more energy efficient appliances. The energy library offers the customer detailed information about everything from compact fluorescent lights to attic insulation. The website also has a bill analyzer tool that allows customers to take a closer look at why one bill was higher than another and understand how much weather or changes in the home may have affected the bill.
- Compact Fluorescent Light Bulb Initiative: In fall 2007, PPL EU delivered more than 150,000 energy efficient compact fluorescent light bulbs (CFLs) to customers who completed profiles on the Energy Analyzer to find ways they could save energy in their homes and businesses. Those light bulbs could save customers more than $8 million and 77 million kWh of electricity before they burn out. PPL EU also delivered special CFL recycling containers to more than 160 municipalities as part of an Earth Day initiative to encourage safe disposal of these bulbs.
- On-site Energy Generation: In addition to helping customers reduce energy demand from PPL-supplied electricity, PPL EU has developed and installed a significant number and variety of on-site customer energy projects to help them control their electric demand. These include on-site natural gas, biogas, and solar energy customer installations. PPL EU plans to invest more than $100 million over the next five years in renewable energy projects. One of PPL EU's 2007 customer renewable energy projects was selected as a "Project of the Year" by the U.S. Environmental Protection Agency.
- ENERGY STAR: PPL EU is a partner in the federal government's ENERGY STAR® program to promote energy efficiency and the wise use of electricity. With the help of ENERGY STAR, Americans saved an estimated $14 billion on their utility bills in 2006 .
- Customer Energy Education: Each issue of PPL EU's Connect newsletter, which accompanies PPL EU's 1.4 million customer bills each month, includes a focus on energy saving tips. PPL EU has also begun a new Speakers Bureau, delivering presentations on energy efficiency to community groups throughout PPL EU's service area.

Demand-side management programs are generally more effective in moderating peak demand, and would not be expected to displace the need for a 1,600 MW baseload power such as would be provided by BBNPP. For these reasons, PPL does not consider energy conservation to represent a reasonable alternative to the BBNPP.

Reactivating or Extending Service Life of Existing Plants (BBNPP ER 9.2.1.2)

Retired fossil fuel power generating facilities and fossil fuel power generating facilities slated for retirement may not be economically viable, particularly in meeting today's restrictions on air contaminant emissions. Because of increasingly stringent environmental restrictions, delaying retirement or reactivating power generating facilities in order to compensate for the closure of a large baseload facility would require major construction to upgrade or replace facility components. There are a number of planned retirements in the PJM service area. None of these retired power generating facilities would be able to supply the necessary 1,600 MW of baseload capacity and, in accordance with the Federal Energy Regulatory Commission (FERC) order, PJM cannot compel the owners of units proposed for retirement to remain in service. Such retirements may take effect upon 90 days prior notice. Therefore, reactivating or extending the service life of existing baseload plants is not a feasible alternative to the BBNPP.

Purchasing Power from Other Utilities or Power Generators (BBNPP ER 9.2.1.3)

In PJM, market participants wishing to buy and sell energy have multiple options. Market participants decide whether to meet their energy needs through self-supply, bilateral purchases from generation owners or market intermediaries, through the day-ahead market or the real-time balancing (that is, spot) market. Energy purchases can be made over any timeframe from instantaneous real-time balancing market purchases to long-term, multi-year bilateral contracts. Purchases may be made from generation located within or outside the PJM RTO region. Market participants also decide whether and how to sell the output of their generation assets. Generation owners can sell their output within the PJM RTO region or outside the region and can use generation to meet their own loads, to sell into the spot market or to sell bilaterally. Generation owners can sell their output over any timeframe from the real-time spot market to multi-year bilateral arrangements. Market participants can use increment and decrement bids in the day-ahead market to hedge positions or to arbitrage expected price differences between markets (PJM, 2008b). In addition, each RTO has a commitment to control its generation in a manner so as not to burden the interconnected systems. Failure to provide adequate control can result in deviations in frequency and inadvertent power flow, stability issues, or transmission constraints.

The policy of PJM is to maintain, at all times, the integrity of the PJM RTO transmission systems and the Eastern Interconnection, and to give maximum reasonable assistance to adjacent systems when a disturbance that is external to the PJM RTO region occurs. Power system disturbances are most likely to occur as the result of loss of generating equipment, transmission facilities, or as the result of unexpected load changes. These disturbances may be of, or develop into, a magnitude sufficient to affect the reliable operation of the PJM RTO region and/or the Eastern Interconnection. These events demand timely, decisive action to prevent further propagation of the disturbance. At these times, PJM must either purchase energy from outside the PJM RTO region, as needed, or sell energy to other RTOs as requested during disturbance condition. When the purchasing of energy is needed, PJM uses its best efforts to acquire the lowest priced energy available at the time (PJM, 2008c).

Under the purchased power alternative, therefore, environmental impacts would still occur, but they would originate from a baseload power generating facility located elsewhere in the region.

Because of existing constraints on west-to-east power transfers within PJM, the purchased power alternative would likely necessitate additional high voltage (that is, 345 or 500 kV) transmission lines to route power from the remote locations in the PJM region to the intended primary market area. PPL anticipates that most of the transmission lines could be routed along existing rights-of-way. In such cases, the environmental impacts of transmission line construction would be moderate to large. ("Moderate"and "large" are defined by the NRC as follows: *Moderate* - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource. *Large* - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource. (NRC, 2001).)

Otherwise, impacts would be large for new line construction. Because baseload generating capacity available for purchase in western PJM is typically fossil-fired, the environmental impacts of emissions due to operation of this fossil-fired capacity for purchased power to replace the BBNPP would be large. Purchasing power from other utilities or power generators has been identified as inconsistent with the objectives of the BBNPP; therefore, it is not described in more detail.

Because of transmission constraints with import of electricity from nearby areas, purchasing power from other utilities or power generators is not considered economically practicable.

The alternative of electric power generating capacity through the *combination* of purchased power and the reactivation or extended service life of power generating facilities within the primary market area is not feasible because of the insufficient capacity of power available for purchase from other local utilities or power generators, or inability to transport available power to the ROI/primary market area during periods of grid congestion. Also, the lack of inventory of deactivated power generating facilities or the possibility of extending the service life of a facility scheduled for deactivation in the future is also not feasible (PPL, 2006).

Alternatives That Require New Generating Capacity (BBNPP ER 9.2.2)

Although many methods are available for generating electricity and many combinations or mixes can be assimilated to meet system needs, such expansive consideration would be too unwieldy to reasonably examine in depth given the purposes of this alternatives analysis. The alternative energy sources considered here are as follows:

- Wind

- Geothermal
- Hydropower
- Solar power
    - Concentrating solar power systems
    - Photovoltaic (PV) cells
- Wood waste
- Municipal solid waste
- Energy crops
- Petroleum liquids (oil)
- Fuel cells
- Coal
- Natural gas
- Integrated gasification combined cycle (IGCC)

Based on the installed capacity of 1,600 MW that BBNPP would produce, not all of the above-listed alternative sources are competitive or viable. As a renewable resource, solar and wind energies have gained increasing popularity over the years, in part because of concern over greenhouse gas emissions. Air emissions from solar and wind facilities are much smaller than fossil fuel air emissions. Although the use of coal and natural gas has undergone a slight decrease in popularity, they remain two of the most widely used fuels for producing electricity.

This section identifies alternatives that PPL has determined are not viable and the basis for this determination. The Combined License Application is premised on the installation of a facility that would serve as a merchant baseload resource and that any feasible alternative would need to be able to generate equivalent baseload power. In performing this evaluation, PPL has utilized information from the NRC Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants (NRC, 1996).

The GEIS is useful for the analysis of alternative sources because NRC has determined that the technologies of these alternatives will enable the agency to consider the relative environmental consequences of an action given the environmental consequences of other activities that also meet the purpose of the proposed action. To generate the set of reasonable alternatives that are considered in the GEIS, common generation technologies were included and various state energy plans were consulted to identify the alternative generation sources typically being considered by state authorities across the country.

From this review, a reasonable set of alternatives to be examined was identified. These alternatives included wind energy, geothermal energy, hydroelectricity, solar energy, incineration of wood waste and municipal solid waste, energy crops, oil, fuel cells, coal, natural gas, and delayed retirement of existing non-nuclear plants. These alternatives were considered pursuant to the statutory responsibilities imposed under the National Environmental Policy Act of 1969 (NEPA) (NEPA, 1982).

Although the GEIS is provided for license renewal, the alternatives analysis in the GEIS can be compared with the proposed action to determine if the alternative represents a reasonable alternative to the proposed action.

Each of the alternatives is discussed in the subsequent sections relative to the following criteria:

- The alternative energy conversion technology is developed, proven, and available in the relevant region within the life of the Combined License.
- The alternative energy source provides baseload generating capacity equivalent to the capacity needed and to the same level as the proposed nuclear plant.
- The alternative energy source does not create more environmental impacts than a nuclear plant would, and the costs of an alternative energy source do not make it economically impractical.

All of the potential alternative technologies considered in this analysis are consistent with national policy goals for energy use and are not prohibited by federal, state, or local regulations. Based on one or more of the criteria described above, several of the alternative energy sources were considered technically or economically infeasible after a preliminary review and were not considered further. Alternatives considered to be technically and economically feasible are described in greater detail under Assessment of Reasonable Alternative Energy Sources and Systems.

♦ Wind (BBNPP ER 9.2.2.1)

In general, areas identified by the National Renewable Energy Laboratory (NREL) as wind resource Class 4 and above are regarded as potentially economical for wind energy production with current technology. Class 4 wind resources are defined as having mean wind speeds between 15.7 and 16.8 mph (25.3 to 27.0 kph) at 50 m elevation (AWEA, 2008).

As a result of advances in technology and the current level of financial incentive support, a number of additional areas with slightly lower wind resources (Class 3+) may also be suitable for large-scale wind development. These would, however, operate at an even lower annual capacity factor and output than used by NREL for Class 4 sites.

Wind turbines must be sufficiently spaced to maximize capture of the available wind energy. If the turbines are too close together, one turbine can impact the efficiency of another turbine. A 2 MW turbine requires approximately 0.25 ac (0.1 ha) of dedicated land for placement of the wind turbine, leaving landowners with the ability to utilize the remaining acreage for some other uses that do not impact the turbine, such as agricultural use (AE, 2008).

The majority of land area throughout the primary market area is characterized as a Class 1 site with scattered areas of Class 2 and Class 3 sites (EERE, 2003).

Although wind technology is considered mature, technological advances may make wind a more economic choice than other renewable sources for developers (CEC, 2003). Technological improvements in wind turbines have helped reduce capital and operating costs. In 2000, wind power was produced at a cost between $0.03 and $0.06/kWh, depending on wind speeds. By 2020, wind power production costs are projected to decrease to between $0.03 and $0.04/kWh (ELPC, 2001). The following contains information about the viability of the wind resource.

- In 1995, the EIA estimated the cost of building a 115 kV line to be $130,000 per mile, excluding rights-of-way costs (EIA, 2003b). Besides construction, operating, and maintenance costs for wind farms, there are also costs for connection to the transmission grid. In 1993, the cost of constructing a new substation for a 115 kV transmission line was estimated at $1.08 million, and the cost of connection for a 115 kV transmission line with a substation was estimated to be $360,000. The farther a wind energy development project is from transmission lines, the higher the cost of connection to the transmission and distribution system. The distance from transmission lines at which a wind developer can profitably build depends on the cost of the specific project (EIA, 1995).
- A wind project would have to be located where the project would produce economical generation, and that location may be far removed from the nearest possible connection to the transmission system. A location far removed from the power transmission grid might not be economical, because new transmission lines would be required to connect the wind farm to the distribution system. Existing transmission infrastructure may need to be upgraded to handle the additional supply. Soil conditions and the terrain must be suitable for the construction of the towers' foundations. Finally, the choice of a location may be limited by land use regulations and the ability to obtain the required permits from local, regional, and national authorities.
- Additional considerations on the integration of wind capacity into the electric utility system are the limitations of wind energy generation. Wind power generating facilities must be located at sites with specific characteristics to maximize the amount of wind energy captured and electricity generated (ELPC, 2001). Additionally, for transmission purposes, wind generation is not considered "dispatchable," meaning the generator can control output to match load and economic requirements. Because the resource is intermittent (or not available all of the time), wind by itself, even with an attached storage system to store energy captured at any time for later use, is not considered a firm source of baseload capacity. The inability of wind alone to be a dispatchable, baseload producer of electricity is inconsistent with the objectives for the BBNPP; however, wind can be used in combination with other resources. This is discussed further Under Assessment of Reasonable Alternative Energy Sources and Systems, Combination of Alternatives.

In addition to the land requirements posed by large facilities, wind power generating facilities have the following potential environmental impacts:

- Some people consider large-scale commercial wind farms to be an aesthetic problem. Local residents near the wind farms may lose what they consider their pristine scenic viewshed of the area.
- High-speed wind turbine blades can be noisy.
- Wind power generating facilities can expect to have higher bird fatality rates than those expected if the facility were not there.

Although Wind Powering America indicates that Pennsylvania has wind resources consistent with utility-scale production in a few areas of the state, near Lake Erie and on ridge crests in the southwestern part of the state, and southwest and southeast of Altoona, they are classified as fair winds (Class 3) at a maximum (EERE, 2008a).

Wind Powering America indicates that Delaware has wind resources consistent with utility-scale production. The good to excellent wind resource is located along the coasts of Delaware Bay and the Atlantic Ocean, especially from Cape Henlopen to the Maryland border. In addition, small wind turbines may have applications in some areas (EERE, 2008b).

Wind Powering America indicates that the highest resources areas in New Jersey are found along the Atlantic Ocean and Delaware Bay coastal areas, and on the ridges of western and northwestern New Jersey. In addition, small wind turbines may have applications in some areas (EERE, 2008c).

Wind Powering America indicates that Maryland has wind resources consistent with utility-scale production. Several areas are estimated to have good to excellent wind resources. These are the barrier islands along the Atlantic coast, the southeastern shore of Chesapeake Bay, and ridge crests in the western part of the state, west of Cumberland. In addition, small wind turbines may have applications in some areas (EERE, 2008d).

Wind Powering America indicates that Virginia has wind resources consistent with utility-scale production. Several areas of the state are estimated to have good to excellent wind resource. In addition, small wind turbines may have applications in some areas (EERE, 2008e).

Many renewable resources, like wind, are intermittent. Storing energy from renewable resources allows supply to match demand. For example, a storage system attached to a renewable resource, such as a wind turbine, could store energy captured at any time, and then utilize that energy during higher priced midday usage (NREL, 2006).

With the inability of wind energy alone to be a dispatchable, baseload producer of power; the cost factors in construction, operation, and transmission connections; and the environmental impacts associated with development, a wind power generating facility alone is not a feasible alternative to the BBNPP and, therefore, is not carried forward for further analysis.

♦ **Geothermal (BBNPP ER 9.2.2.2)**

The GEIS (NRC, 1996) indicates that geothermal plants might be located in the western continental U.S., Alaska, and Hawaii, where hydrothermal reservoirs are prevalent; however, suitable geothermal resources do not exist in the ROI/primary market area.

Based on the hottest known geothermal regions of the U.S., the ROI/primary market area is not a candidate for geothermal energy and could not produce the proposed 1,600 MW of baseload energy (GEO, 2000). Delaware and Maryland have vast low-temperature resources suitable for geothermal heat pumps. However, neither state has sufficient resources to use other geothermal technologies (EERE, 2008b) (EERE, 2008d). Pennsylvania, New Jersey, and Virginia have low to moderate temperature resources that can be tapped for direct heat or for geothermal heat pumps (EERE, 2008a) (EERE, 2008c) (EERE, 2008e) but they are not adequate for the baseload power requirements. Therefore, a geothermal energy source is not adequate in the ROI/primary market area, and a geothermal power generating facility is not a feasible alternative. As a result, this energy source is not carried forward for further analysis.

♦ **Hydropower (BBNPP ER 9.2.2.3)**

The GEIS estimates land use of 1,600 mi^2 (4,144 km^2) per 1,000 MW generated by hydropower. Based on this estimate, hydropower would require flooding more than 2,600 mi^2 (6,734 km^2) to produce a baseload capacity of 1,600 MW, resulting in a large impact on land use.

Environmental considerations associated with hydropower dams include alteration of aquatic habitats above and below the dam, which would affect existing aquatic species, and the constraint the dam puts on migrating fish species in the area. Another consideration is the potential displacement of communities by flooding the new reservoir, or local communities' loss of use of the current river system for recreational activities.

Pennsylvania has 104 hydropower sites with the potential for 2,217.3 MW of electricity. Sixty- seven of the sites have been developed with an impoundment or diversion structure, but are currently without power generation capability. These have a potential for 309.8 MW of electricity. Thirty-two of the sites are undeveloped (no impoundment or diversion structure and no power generation capability) with a potential for 1,700.6 MW of electricity. Five of the sites have been developed with power generation capability and have the potential for 206.9 MW of additional capacity. In order to produce the 1,600 MW of baseload capacity required by the BBNPP, numerous hydropower generating facilities would need to be developed and in operation (INEEL, 1997). Virginia has a total of 88 hydropower facilities with the potential for generating 1,250 MW (INEEL, 1997a). Delaware’s potential for hydropower generation is negligible (INEEL, 1997b). Maryland has a total of 36 hydropower facilities with the potential of producing 230 MW (INEEL, 1997c). New Jersey has a total of 12 hydropower facilities with a potential of producing 11 MW (INEEL, 1997d).

Pennsylvania, Delaware, New Jersey, and Maryland have low hydropower resource as a percentage of the state's electricity generation (EERE, 2008a) (EERE, 2008b) (EERE, 2008c) (EERE, 2008d). Virginia has moderate hydropower resource as a percentage of the state's electricity generation (EERE, 2008e).

Because hydropower is not a feasible alternative due to substantial land use requirements, this energy source is not carried forward for further analysis.

- **Solar Power (BBNPP ER 9.2.2.4)**

Solar energy depends on the availability and strength of sunlight (strength is measured as kWh/m^2), and solar power is considered an intermittent source of energy. Solar facilities would have equivalent or greater environmental impacts than a new nuclear facility at the BBNPP site. Such facilities would also have higher costs than a new nuclear facility. The construction of solar power-generating facilities has substantial impacts on natural resources (such as wildlife habitat, land use, and aesthetics). As stated in the GEIS, land requirements are high: 35,000 ac (14,000 ha) per 1,000 MW for PV cells and approximately 14,000 ac (6,000 ha) per 1,000 MW for solar thermal systems. This would require a footprint of approximately 56,000 ac (22,700 ha) for PV cells and 22,400 ac (9,100 ha) for solar thermal systems to produce a 1,600 MW baseload capacity. Both of these alternatives would increase environmental impacts by constructing on a much larger footprint area.

In the ROI, two types of collectors for solar resources were considered: concentrating collectors and flat-plate collectors. Concentrating collectors are mounted to a tracker, which allows them to face the sun at all times of the day. In the ROI/primary market area, approximately 3,000 to 3,500 watt hours per square meter per day ($W(hr)/m^2/day$) can be collected using concentrating collectors (EERE, 2008f). Flat-plate collectors are usually fixed in a tilted position to best capture direct rays from the sun and also to collect reflected light from clouds or off the ground. In the ROI/primary market area, approximately 4,000 to 4,500 $W(hr)/m^2/day$ can be collected using flat-plate collectors (EERE, 2008f). For flat-plate collectors, Pennsylvania has a useful resource across the state. For concentrating collectors, Pennsylvania resource is relatively poor (EERE, 2008a). For flat-plate collectors, Delaware has a useful resource throughout the state. For concentrating collectors, Delaware has a marginal resource (EERE, 2008b). For flat-plate collectors, New Jersey has a useful resource; southern New Jersey has the best resource. For concentrating collectors, New Jersey has a marginal resource (EERE, 2008c). For flat-plate collectors, Maryland has a good, useful solar resource throughout the state. For concentrating collectors, Maryland has a marginal resource (EERE, 2008d). For flat-plate collectors, Virginia has good, useful solar resource throughout most of the state. For concentrating collectors, Virginia could pursue some types of technologies in the south central region of the state (EERE, 2008e). The footprint needed to produce a 1,600 MW baseload capacity is much too large to construct at the proposed plant site.

Environmental impacts of solar power systems can vary based on the technology used and the site-specific conditions.

- Land use and aesthetics are the primary environmental impacts of solar power.
- Land requirements for each of the individual solar energy technologies are large, compared with the land used by a new nuclear plant.
- Depending on the solar technology used, there may be thermal discharge impacts. These impacts are anticipated to be small. During operation, PV and solar thermal technologies produce no air pollution, little or no noise, and require no transportable fuels.
- PV technology creates environmental impacts related to manufacture and disposal. Chemicals used in the manufacture of PV cells include cadmium and lead. Potential human health risks also arise from the manufacture and deployment of PV systems because there is a risk of exposure to heavy metals such as selenium and cadmium during use and disposal (CEC, 2004). There is some concern that landfills could leach cadmium, mercury, and lead into the environment in the long term.
- Generally, PV cells are sealed and the risk of release is considered slight; however, the long-term impact of these chemicals in the environment is unknown. Another environmental consideration with solar technologies is the lead-acid batteries that are used with some systems. The impact of these lead batteries is lessening; however, as batteries become more recyclable, batteries of improved quality are produced and better quality solar systems that enhance battery lifetimes are created (REW, 2001).

Based on the large facility footprint needed to produce a 1,600 MW baseload capacity, as well as the early stage of development of the technology, solar power systems are not considered competitive to the proposed project and are not carried forward for further analysis.

<u>Concentrating Solar Power Systems (BBNPP ER 9.2.2.4.1)</u>

Concentrating solar plants produce electric power by converting solar energy into high temperature heat using various mirror configurations. The heat is then channeled through a conventional generator, via an intermediate medium (i.e., water or salt). Concentrating solar plants consist of two parts: one that collects the solar energy and converts it to heat, and another that converts heat energy to electricity.

Concentrating solar power systems can be sized for "village" power (10 kWe) or grid connected applications (up to 100 MW). Some systems use thermal energy storage, setting aside heat transfer fluid in its hot phase during cloudy periods or at night. These attributes, along with solar-to-electric conversion efficiencies, make concentrating solar power an attractive renewable energy option in the southwest part of the U.S. and other Sunbelt regions worldwide (EERE, 2006b). Others can be combined with natural gas. This type of combination is discussed under Combination of Alternatives, below.

There are three kinds of concentrating solar power systems – troughs, dish/engines, and power towers – classified by how they collect solar energy (EERE, 2006b). Concentrating solar power technologies utilize many of the same technologies and equipment used by conventional power plants, simply substituting the concentrated power of the sun for the combustion of fossil fuels to provide the energy for conversion into electricity. This "evolutionary" aspect – as distinguished from "revolutionary" or "disruptive" – allows for easy integration into the transmission grid. It also makes concentrating solar power technologies the most cost-effective solar option for the production of large-scale electricity generation (10 MW and above).

In 2005, concentrating solar power systems had a benchmark cost of $0.12 to $0.14/kWh with a target cost of $0.035 to $0.06/kWh by 2025 (EERE, 2006a). However, concentrating solar power generating facilities are still in the demonstration phase of development, are not currently competitive with nuclear based technologies, and are not carried forward for further analysis.

"Flat-Plate" Photovoltaic Cells (BBNPP ER 9.2.2.4.2)

The second common method for capturing the sun's energy is through the use of PV cells. A typical PV or solar cell might be a square that measures about 10 cm (4 in) on a side. A cell can produce about 1 watt of power-more than enough to power a watch, but not enough to run a radio.

When more power is needed, some 40 PV cells can be connected to form a "module." A typical module is powerful enough to light a small light bulb. For larger power needs, about 10 such modules are mounted in PV arrays, which can measure up to several meters on a side. The amount of electricity generated by an array increases as more modules are added.

"Flat-plate" PV arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture more sunlight over the course of a day. Ten to 20 PV arrays can provide enough power for a household; for large electric utility or industrial applications, hundreds of arrays can be interconnected to form a single, large PV system (NREL, 2007). The land requirement for this technology is approximately 14 hectares (35 acres) per MW (NRC, 1996). In order to produce the 1,600 MW baseload capacity as BBNPP, 22,660 hectares (55,993 acres) would be required for construction of the photovoltaic modules.

Some PV cells are designed to operate with concentrated sunlight, and a lens is used to focus the sunlight onto the cells. This approach has both advantages and disadvantages compared with flat-plate PV arrays. Economics of this design turn on the use of as little of the expensive semi-conducting PV material as possible, while collecting as much sunlight as possible. The lenses cannot use diffuse sunlight, but must be pointed directly at the sun and moved to provide optimum efficiency. Therefore, the use of concentrating collectors is limited to the west and southwest areas of the U.S.

Currently, PV solar power is not competitive with other methods of producing electricity for the open wholesale electricity market. When calculating the cost of solar systems, the totality of the system must be examined. There is the price per watt of the solar cell, price per watt of the module (whole panel), and the price per watt of the entire system. It is important to remember that all systems are unique in their quality and size, making it difficult to make broad generalizations about price. The average price for modules (dollars per peak watt) increased 9%, from $3.42 in 2001 to $3.74 in 2002. For cells, the average price decreased 14%, from $2.46 in 2001 to $2.12 in 2002 (EIA, 2003a). The module price, however, does not include the design costs, land, support structure, batteries, an inverter, wiring, and lights/appliances.

Costs of PV cells in the future may decrease with improvements in technology and increased production. By 2020, costs of grid-connected PV systems could drop to $2,275 per kWe and to $0.15 to $0.20 per kWh by 2020 (ELPC, 2001). These costs would still be substantially in excess of the costs of power from a new nuclear plant. Therefore, PV cells are not competitive with a new nuclear plant at the BBNPP site and are not carried forward for further analysis.

♦ Wood Waste and Other Biomass (BBNPP ER 9.2.2.5)

The use of wood waste and other biomass to generate electricity is largely limited to states with significant wood resources, such as California, Maine, Georgia, Minnesota, Oregon, Washington, and Michigan. Electric power is generated in these states by the pulp, paper, and paperboard industries, which consume wood and wood waste for energy, benefiting from the use of waste materials that could otherwise represent a disposal problem. However, the largest wood waste power plants are 40 to 50 MW in size. This would not meet the proposed 1,600 MW baseload capacity.

Nearly all of the wood-energy-using electricity generation facilities in the U.S. use steam turbine conversion technology. The technology is relatively simple to operate and it can accept a wide variety of biomass fuels. Therefore, the technology is primarily used in the applications where there is a readily available supply of low, zero, or negative cost delivered feedstock.

As indicated in the GEIS, construction of a wood-fired plant would have an environmental impact that would be similar to that for a coal-fired plant. Like coal-fired plants, wood waste plants require large areas for fuel storage, processing, and waste (i.e., ash) disposal. Additionally, the operation of wood-fired plants creates environmental impacts, including impacts on the aquatic environment and air (NRC, 1996).

The availability of biomass resources in Pennsylvania are as follows in thousand metric tons/year (thousand tons/year): Crop residues: 735 (810); switchgrass on Conservation Reserve Program (CRP) lands: 610 (672); forest residues: 1,523 (1,679); methane from landfills: 582 (642); methane from manure management: 21 (23); primary mill: 1,231 (1,358); secondary mill: 115 (127); urban wood: 1,123 (1,238); and methane from domestic wastewater: 18 (20). This totals approximately 5,959 thousand metric tons/year (6,569 thousand tons/year)) total biomass availability in the Commonwealth of Pennsylvania (NREL, 2005).

According to a technical report (NREL, 2005), the availability of biomass resources in Delaware are as follows in thousand metric tons/year (thousand tons/year): Crop residues: 222 (245); switchgrass on CRP lands: 20 (22); forest residues: 47 (51); methane from landfills: 53 (58); methane from manure management: 0.5 (0.5); primary mill: 0.05 (0.05); secondary mill: 7 (8); urban wood: 77 (85); and methane from domestic wastewater: 0.9 (1). This totals approximately 437 thousand metric tons/year (482 thousand tons/year)) total biomass availability in the State of Delaware (NREL, 2005).

Data in the NREL report shows the availability of biomass resources in New Jersey are as follows in thousand metric tons/year (thousand tons/year): Crop residues: 83 (91); switchgrass on CRP lands: 10 (11); forest residues: 26 (29); methane from landfills: 451 (497); methane from manure management: 0.3 (0.3); primary mill: 15 (17); secondary mill: 811 (894); urban wood: 566 (624); and methane from domestic wastewater: 13 (14). This totals approximately 1,462 thousand metric tons/year (1,612 thousand tons/year)) total biomass availability in the State of New Jersey.

The availability of biomass resources in Maryland, according to the same report, are as follows in thousand metric tons/year (thousand tons/year): Crop residues: 530 (584); switchgrass on CRP lands: 246 (271); forest residues: 239 (263); methane from landfills: 185 (204); methane from manure management: 5.4 (6); primary mill: 125 (138); secondary mill: 30 (33); urban wood: 566 (624); and methane from domestic wastewater: 8.2 (9). This totals approximately 1,933 thousand metric tons/year (2,131 thousand tons/year)) total biomass availability in the State of Maryland.

According to the NREL report, the availability of biomass resources in Virginia are as follows in thousand metric tons/year (thousand tons/year): Crop residues: 455 (502); switchgrass on CRP lands: 269 (297); forest residues: 2,180 (2,403); methane from landfills: 249 (275); methane from manure management: 21 (23); primary mill: 1,948 (2,147); secondary mill: 56 (62); urban wood: 738 (813); and methane from domestic wastewater: 11 (12). This totals approximately 5,928 thousand metric tons/year (6,535 thousand tons/year)) total biomass availability in the Commonwealth of Virginia.

Biomass fuel can be used to co-fire with a coal-powered generating facility, decreasing cost from $0.023 to $0.021 per kWh. This is only cost effective if biomass fuels are obtained at prices equal to or less than coal prices. In today's direct-fired biomass power plants, generation costs are about $0.09 per kWh (EERE, 2007), which is significantly higher than the costs associated with a nuclear power plant ($0.031 to $0.046 per kWh) (DOE, 2002). Because of the environmental impacts and costs of a biomass-fired plant, biomass is not competitive within the ROI with a new nuclear unit and this energy source is not carried forward for further analysis.

- **Municipal Solid Waste (BBNPP ER 9.2.2.6)**

The initial capital costs for municipal solid waste (MSW) plants are greater than for comparable steam turbine technology at wood-waste facilities (NRC, 1996). This is because of the need for specialized waste separation and handling equipment.

The decision to burn MSW to generate energy is usually driven by the need for an alternative to landfills, rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy because of the numerous obstacles and factors that may limit the growth in MSW power generation. Chief among them are environmental regulations and public opposition to siting MSW facilities.

Estimates suggest that the overall level of construction impacts from a waste-fired plant should be approximately the same as those for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal) (NRC, 1996). Some of these impacts would be moderate, but still larger than the proposed action.

As of March 2008, generation of other renewable electricity, which includes MSW, accounted for the following percentages of total generation in the ROI: 1.2% in Pennsylvania, 1.6% in Delaware, 1.3% in Maryland, and 1.6% in New Jersey (EIA, 2008c). As an MSW reduction method, incineration can be implemented, generating energy and reducing the amount of waste by up to 90% in volume and 75% in weight (USEPA, 2006b).

The U.S. has about 89 operational MSW-fired power generation plants, generating approximately 2,500 MW, or about 0.3% of total national power generation. However, economic factors have limited new construction. This comes to approximately 28 MW per MSW-fired power generation plant, and would not meet the proposed 1,600 MW baseload capacity. Burning MSW produces nitrogen oxides and sulfur dioxide as well as trace amounts of toxic pollutants, such as mercury compounds and dioxins. MSW power plants, much like fossil fuel power plants, require land for equipment and fuel storage. The non-hazardous ash residue from the burning of MSW is typically deposited in landfills (USEPA, 2006a).

The cost of power for MSW fired power generation plants would be partially offset by savings in waste disposal fees. However, MSW-fired power generation remains significantly more costly than nuclear power, even when disposal fee savings are included into the cost of power. A study performed for a proposed MSW-fired power facility in 2002 found that cost of power varied from $0.096 to $0.119¢ per kWh in the case with low MSW disposal fees, and from $0.037 to $0.055 per KWh in the case with high MSW disposal fees (APT, 2004). These costs, accounting for the disposal fees, are significantly higher than the costs associated with a nuclear power plant ($0.031 to $0.046 per kWh) (DOE, 2002).

MSW is not competitive with a new nuclear unit at the BBNPP site and this energy source is not carried forward for further analysis.

- **Energy Crops (BBNPP ER 9.2.2.7)**

In addition to wood and MSW fuels, there are several other concepts for fueling electric generators, including burning energy crops, converting crops to a liquid fuel such as ethanol (ethanol is primarily used as a gasoline additive), and gasifying energy crops (including wood waste). None of these technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant capacity of 1,600 MW.

Estimates suggest that the overall level of construction impacts from a crop-fired plant should be approximately the same as those for a wood-fired plant. Additionally, crop-fired plants would have similar operational impacts (including impacts on the aquatic environment and air) (NRC, 1996). In addition, these systems have large impacts on land use because of the acreage needed to grow the energy crops.

Ethanol is perhaps the best known energy crop. It is estimated that 3.0 mi^2 (7.69 km^2) of corn are needed to produce 1 million gallons of ethanol and in 2002, Pennsylvania produced approximately 2,073 mi^2 (5,369 km^2) of corn. Currently in Pennsylvania, more corn is used for grain products than any other purpose. Pennsylvania produces more than 50% of the corn grown in the ROI. If ethanol were to be proposed as an energy crop, Pennsylvania would have to supplement its corn production from nearby states (USDA, 2004). Surrounding states within the ROI also use corn for grain products and do not have the resources to supplement ethanol based fuel facilities.

The energy cost per KWh for energy crops is estimated to be similar to, or higher than, other biomass energy sources (EIA, 2004). A DOE forecast concluded that the use of biomass for power generation is not projected to increase substantially in the next 10 years because of the cost of biomass relative to the costs of other fuels and the higher capital costs relative to those for coal- or natural-gas-fired capacity (EIA, 2002). Therefore, energy crops are not competitive with a new nuclear unit at the BBNPP site and this energy source is not carried forward for further analysis.

- **Petroleum Liquids (Oil) (BBNPP ER 9.2.2.8)**

From 2002 to 2005, petroleum costs almost doubled, increasing by 92.8%, and the period from 2004 to 2005 alone produced an average petroleum increase of 50.1% (EIA, 2006). Between January 2006 and January 2008, petroleum costs tripled, increasing by approximately 195 percent (EIA, 2007c) (EIA, 2008b). In spite of the increase in the cost of petroleum, Pennsylvania experienced an increase in production of electricity by power-generating facilities fueled by oil. However, from 2005 to 2006, net generation of electricity from petroleum liquids dropped by about 84% in Maryland (EIA, 2007d).

As of March 2008, generation of petroleum fired electricity accounted for only a small percentage of total generation in the ROI: 0.4% in Pennsylvania, 3.5% in Delaware, 0.4% in Maryland, and 0.8% in New Jersey. Between January 2007 and January 2008, net generation from petroleum liquids increased by 82% (EIA, 2008a). In the GEIS, NRC staff estimated that construction of a 1,000 MW oil power generating facility would require approximately 120 ac (50 ha) of land.

Operation of oil-fired plants would have environmental impacts (including impacts on the aquatic environment and air) that would be similar to those from a coal-fired plant. Oil fired plants also have one of the largest carbon footprints of all the electricity generation systems analyzed. Conventional oil-fired plants result in emissions of greater than 650 grams of CO_2 equivalent/kilowatt-hour (gCO_2eq/kWh). This is approximately 130 times higher than the carbon footprint of a nuclear power generation facility (approximately 5 gCO_2eq/kWh). Future developments such as carbon capture and storage and co-firing with biomass have the potential to reduce the carbon footprint of oil-fired electricity generation (POST, 2006).

Apart from fuel price, the economics of oil fired power generation are similar to those for natural gas fired power generation. Distillate oil can be used to run gas turbines in a combined cycle system; however, the cost of distillate oil usually makes this type of combined cycle system a less competitive alternative when natural gas is available. Oil fired power generation experienced a significant decline in the early 1970s. Increases in world oil prices have forced utilities to use less expensive fuels; however, oil fired generation is still an important source of power in certain regions of the U.S. (NRC, 1996).

On these bases, an oil-fired generation plant is not competitive with a new nuclear unit at the BBNPP site and this energy source is not carried forward for further analysis.

- **Fuel Cells (BBNPP ER 9.2.2.9)**

Phosphoric acid fuel cells are the most mature fuel cell technology, but they are only in the initial stages of commercialization. During the past three decades, significant efforts have been made to develop more practical and affordable fuel cell designs for stationary power applications, but progress has been slow. Today, the most widely marketed fuel cells cost about $4,500 per kWh of installed capacity.

By contrast, a diesel generator costs $800 to $1,500 per kWh of installed capacity, and a natural gas turbine may cost even less. DOE has launched an initiative - the Solid State Energy Conversion Alliance - to bring about dramatic reductions in fuel cell cost. The DOE's goal is to cut costs to as low as $400 per kWh of installed capacity by the end of this decade, which would make fuel cells competitive for virtually every type of power application (DOE, 2006).

As market acceptance and manufacturing capacity increase, natural-gas-fueled fuel-cell plants in the 50 to 100 MW range are projected to become available. This will not meet the proposed 1,600 MW(e) baseload capacity. At the present time, fuel cells are not economically or technologically competitive with other alternatives for baseload electricity generation and the fuel cell alternative is not competitive with a new nuclear unit at the BBNPP site. As a result, this energy source is not carried forward for further analysis.

- **Coal (BBNPP ER 9.2.2.10)**

Coal-fired steam electric plants provide the majority of electric generating capacity in the U.S., accounting for about 52% of the electric utility industry's total generation, including co-generation, in 2000 (EIA, 2001). Conventional coal-fired plants generally include two or more generating units and have total capacities ranging from 100 MW to more than 2,000 MW. Coal is likely to continue to be a reliable energy source well into the future, assuming environmental constraints do not cause the gradual substitution of other fuels (EIA, 1993).

The U.S. has abundant low-cost coal reserves, and the price of coal for electric generation is likely to increase at a relatively slow rate. Even with recent environmental legislation, new coal capacity is expected to be an affordable technology for reliable, near-term development and for potential use as a replacement technology for nuclear power plants (NRC, 1996).

The environmental impacts of constructing a typical coal-fired steam plant are well known because coal is the most prevalent type of central generating technology in the U.S. The impacts of constructing a 1,000 MW coal plant at a greenfield site can be substantial, particularly if it is sited in a rural area with considerable natural habitat. An estimated 1,050 acres (425 ha) or 1.64 mi^2 (4.25 km^2) would be needed at the BBNPP for a new 1,600 MW coal-fired facility, including power block, coal storage, and waste management, resulting in the loss of the same amount of natural habitat and/or agricultural land for the plant site alone, excluding land required for mining and other fuel cycle impacts (NRC, 2008).

As of March 2008, generation of coal-fired electricity accounted for the following percentages of total generation in the ROI: 57.2% in Pennsylvania, 76.5% in Delaware, 62.1% in Maryland, and 17.1% in New Jersey (EIA, 2008c). An existing coal-fueled power plant usually averages about $0.023/kWh. However, co-firing with inexpensive biomass fuel can decrease the cost to $0.021/kWh. This is only cost effective if biomass fuels are obtained at prices equal to or less than coal prices (EERE, 2007).

The operating impacts of new coal plants would be substantial for several resources. Concerns over adverse human health effects from coal combustion have led to important federal legislation in recent years, such as the Clean Air Act and Amendments. Although new technology has improved emissions quality from coal-fired facilities, health concerns remain. Air quality would be degraded by the release of additional carbon dioxide, regulated pollutants, and radionuclides.

Carbon dioxide has been identified as a leading cause of global warming. Sulfur dioxide and oxides of nitrogen have been identified with acid rain. Substantial solid waste, especially fly ash and scrubber sludge, would be produced and would require constant management. Losses to aquatic biota would occur through impingement and entrainment and discharge of cooling water to natural water bodies. However, the positive socioeconomic benefits can be considerable for surrounding communities in the form of several hundred new jobs, substantial tax revenues, and plant spending.

Based on the well-known technology, fuel availability, and generally understood environmental impacts associated with constructing and operating a coal gas-fired power generation plant, it is considered a competitive alternative and is therefore discussed further under Assessment of Reasonable Alternative Energy Sources and Systems, below.

- **Natural Gas (BBNPP ER 9.2.2.11)**

As of March 2008, generation of natural gas-fired electricity accounted for the following percentages of total generation in the ROI: 7.0% in Pennsylvania, 8.3% in Delaware, 2.2% in Maryland, and 32.9% in New Jersey (EIA, 2008c).

Most of the environmental impacts of constructing natural gas-fired plants are similar to those of other large central generating stations. Land-use requirements for gas-fired plants are small, at 0.17 mi^2 (0.45 km^2) for a 1,000 MW plant, so land-dependent ecological, aesthetic, erosion, and cultural impacts should be small. Siting at a greenfield location would require new transmission lines and increased land-related impacts, whereas locating the gas-fired plant with an existing nuclear plant would help reduce land-related impacts. Also, gas-fired plants, particularly combined cycle and gas turbine facilities, take much less time to construct than other plants (NRC, 1996).

Additionally, land use requirements for the BBNPP site would be approximately 160 ac (65 ha) or 0.25 mi^2 (0.65 km^2) for a new 1,600 MW gas-fired plant to be located at the BBNPP site. Another 12 ac (4.9 ha) or 0.02 mi^2 (0.05 km^2) would be required to build a pipeline to connect to an existing pipeline corridor (NRC, 2008).

Based on the well-known technology, fuel availability, and generally understood environmental impacts associated with constructing and operating a natural gas-fired power generation plant, it is considered a competitive alternative and is therefore discussed further under Assessment of Reasonable Alternative Energy Sources and Systems, below.

- **Integrated Gasification Combined Cycle (IGCC) (BBNPP ER 9.2.2.12)**

Integrated Gasification Combined Cycle (IGCC) is an emerging, advanced technology for generating electricity with coal that combines modern coal gasification technology with both gas turbine and steam turbine power generation. The technology is substantially cleaner than conventional pulverized coal plants because major pollutants can be removed from the gas stream prior to combustion.

The IGCC alternative generates substantially less solid waste than the pulverized coal-fired alternative. The largest solid waste stream produced by IGCC installations is slag, a black, glassy, sand-like material that is potentially a marketable byproduct. Slag production is a function of ash content. The other large-volume byproduct produced by IGCC plants is sulfur, which is extracted during the gasification process and can be marketed rather than placed in a landfill. IGCC units do not produce ash or scrubber wastes.

At present, IGCC technology has insufficient operating experience for widespread expansion into commercial-scale, utility applications. Each major component of IGCC has been broadly utilized in industrial and power generation applications. But the integration of coal gasification with a combined cycle power block to produce commercial electricity as a primary output is relatively new and has been demonstrated at only a handful of facilities around the world, including five in the U.S. Experience has been gained with the chemical processes of gasification, coal properties and their impact on IGCC design, efficiency, economics, etc.

However, system reliability is still relatively lower than conventional pulverized coal-fired power plants. There are problems with the integration between gasification and power production, as well. For example, if there is a problem with gas cleaning, uncleaned gas can cause various damages to the gas turbine (PU, 2005).

Overall, IGCC plants are estimated to be about 15% to 20% more expensive than comparably sized pulverized coal plants, due in part to the coal gasifier and other specialized equipment. Recent estimates indicate that overall capital costs for coal-fired IGCC power plants range from $1,400 to $1,800/ kW (EIA, 2005). The production cost of the electricity from a coal-based IGCC power plant is estimated to be about $0.033 to $0.045/kWh. The projected cost associated with operating a new nuclear facility similar to BBNPP is in the range of $0.031 to $0.046/kWh.

In 2004, the DOE commissioned Booz Allen Hamilton to conduct a study on the various ways to increase IGCC's market penetration potential in the future. The study considered only coal as the feedstock. Booz Allen Hamilton concluded that it is feasible for IGCC to assume a more prominent role in energy production only after extensive research is conducted to lower the production costs. Additionally, Booz Allen Hamilton depicted three challenges that IGCC must overcome before becoming a prominent source of energy, including: overcoming the financial burden relative to competing technologies, mitigating siting risks, and managing uncertainty. Booz Allen Hamilton lays out a series of recommendations for the DOE to take to begin to overcome these challenges. Many of these recommendations include conducting further studies and research tests (BAH, 2004).

Because IGCC technology currently requires further research to achieve an acceptable level of reliability, an IGCC facility is not a competitive alternative to BBNPP and is not carried forward for further analysis.

ASSESSMENT OF REASONABLE ALTERNATIVE ENERGY SOURCES AND SYSTEMS (BBNPP ER 9.2.3)

For the viable alternative energy source options identified in Alternatives That Require New Generating Capacity, the issues associated with these options were characterized based on the significance of impacts, with the impacts characterized as being either SMALL, MODERATE, or LARGE. This characterization is consistent with the NRC criteria described above and review here:

- SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
- MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
- LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource (NRC, 2001).

Table 9.2-1, at the end of Section II, provides a comparison of the alternatives regarding environmental categories.

♦ Coal-Fired Generation (BBNPP ER 9.2.3.1)

The environmental impacts from coal-fired generation alternatives were evaluated in the GEIS (NRC, 1996), draft GEIS for license renewal (NRC, 2008), and SSES Units 1 and 2 License Renewal Application (NRC, 2006). It was concluded that construction impacts for coal-fired generation could be substantial, in part because of the large land area required for the plant site alone; 1,050 ac (425 ha) or 1.64 mi^2 (4.25 km^2) would be needed at the BBNPP for a new 1,600 MW coal-fired facility, including power block, coal storage, and waste management (NRC, 2008), which would be in addition to the land resource required for mining and other fuel cycle impacts. These construction impacts would be decreased to some degree by siting a new coal-fired plant where an existing nuclear plant is located.

Air Quality (BBNPP ER 9.2.3.1.1)

The air quality impacts of coal-fired generation are considerably different from those of nuclear power. A coal-fired plant would emit sulfur dioxide (SO2, as SOx surrogate), oxides of nitrogen (NOx), particulate matter (PM), and carbon monoxide (CO), all of which are regulated pollutants. Air quality impacts from fugitive dust, water quality impacts from acidic runoff, and aesthetic and cultural resources impacts are all potential adverse consequences of coal mining.

Air emissions were estimated for a coal-fired generation facility based on the emission factors contained in USEPA document AP-42 (USEPA, 1995). The emissions from this facility are based on a power generation capacity of 1,600 MW. The coal-fired generation facility assumes the use of bituminous coal-fired in a circulating fluidized bed combustor (FBC). The sulfur content of the coal was assumed to be 2% by weight. Emissions control included the use of lime in the combustor unit, a wet scrubber system to control acid gas emissions, selective catalytic reduction to minimize NOx emissions and a baghouse to control PM.

Operating impacts of a new coal plant include concerns over adverse human health effects, such as increased cancer and emphysema. Air quality would be impacted by the release of CO_2, regulated pollutants, and radionuclides. CO_2 has been identified as a leading cause of global warming, and SO_2 and oxides of nitrogen have been identified with acid rain. Substantial solid waste, especially fly ash and scrubber sludge, would be also be produced and would require constant management. Losses of aquatic biota due to cooling water withdrawals and discharges would also occur.

Coal burning power systems have the largest carbon footprint of all the electricity generation systems analyzed. Conventional coal systems result in emissions of greater than 1,000 grams of CO_2 equivalent/kilowatt-hour (gCO_2eq/kWh). This is approximately 200 times higher than the carbon footprint of a nuclear power generation facility (approximately 5 gCO_2eq/kWh). Lower emissions can be achieved using new gasification plants (less than 800 gCO_2eq/kWh), but this is still an emerging technology and not as widespread as proven combustion technologies. Future developments such as carbon capture and storage and co-firing with biomass have the potential to reduce the carbon footprint of coal-fired electricity generation. (POST, 2006)

The NRC indicates that air emission impacts from fossil fuel generation are greater than nuclear power generating facility air emission impacts (NRC, 1996) (NRC, 2006) (NRC, 2008). The NRC notes that human health effects from coal combustion are also greater based on the health effects from air emissions. Based on the emissions generated by a coal-fired facility, air impacts would be MODERATE.

Waste Management (BBNPP ER 9.2.3.1.2)

Substantial solid waste, especially fly ash and scrubber sludge, would be produced during plant operation and would require constant management. Approximately 360 ac (145.7 ha) would be required over a 40-year period of a coal-fired facility at the BBNPP for waste disposal (NRC, 2008).

With proper placement of the facility, coupled with current waste management and monitoring practices, waste disposal would not destabilize any resources. There would also need to be an estimated 34.4 mi^2 (89 km^2) for mining the coal and disposing of the waste to support a coal plant during its operational life (NRC, 1996).

As a result of the above-mentioned factors, waste management impacts would be MODERATE. Impacts from construction wastes, such as debris from land clearing and solid wastes would be SMALL.

Economic Comparison (BBNPP ER 9.2.3.1.3)

DOE has estimated the cost of generating electricity from a coal facility to be approximately $0.049 per kWh. The projected cost associated with operating a new nuclear facility similar to the BBNPP is in the range of $0.031 to $0.046 per kWh.

Although coal-fired generation is considered a competitive alternative to nuclear power generation, coal-fired generation is not considered to be environmentally preferable to the proposed action. Therefore, as allowed in NUREG-1555, ESRP 9.2.3 (NRC, 2007), additional cost data, e.g., decommissioning costs, and fuel cost estimates, are not provided for alternatives that are not deemed to be environmentally preferable to the proposed action.

Other Impacts (BBNPP ER 9.2.3.1.4)

Construction of the power block and coal storage area would disturb approximately 690 ac (279 ha) or 1.1 mi^2 (2.8 km^2) of land and associated terrestrial habitat and 360 ac (146 ha) or 0.6 mi^2 (1.5 km^2) for waste management (NRC, 2008). As a result, land use impacts would be MODERATE during construction and operation.

Impacts to aquatic resources and surface water quality would be minimized but could be characterized as SMALL because of the coal power generating facility's use of a new cooling water system. Losses to aquatic biota would occur through impingement and entrainment and discharge of cooling water to natural water bodies. Impacts from construction activities to surficial groundwater would be localized and SMALL. The groundwater would be expected to recover during operations mode, therefore, impact to groundwater would be SMALL (PPL, 2006) (NRC, 2008). Impacts to surface water bodies would be MODERATE during construction primarily because of loss of wetlands and wetland buffers. Although coal pile runoff could affect surface water quality, impacts to water resources and quality would be SMALL because of the coal power generating facility's use of a new cooling water system. (NRC, 2008)

The BBNPP site is already aesthetically altered by the presence of the existing SSES Units 1 and 2 structures. The power plant buildings would be up to 200 ft (61 m) tall and may be visible in the daylight hours and the exhaust stacks would be up to 600 ft (183 m) tall. Current SSES cooling towers are approximately 540 ft (165 m) tall. The visual impact of the towers could be mitigated through landscaping and light paint color. The aesthetic impact, therefore, would be SMALL during operation (NRC, 2008). Noise impacts during operation would be SMALL to MODERATE (NRC, 2006). Construction activities would not be visible to the public because of highways bordered by vegetation; therefore, impacts would be SMALL to MODERATE (NRC, 2008).

The BBNPP site development would use terrestrial forest, wetland habitat, and land previously disturbed by agriculture near SSES. Permanent and/or temporary impacts to wetlands and/or streams would occur within the project footprint during construction. BMPs would be used to minimize wetlands impacts and wetland construction on PPL-owned or other property would mitigate loss of wetland habitat. Because wetland habitat loss would require mitigation, ecological resource impacts would be MODERATE.

Terrestrial habitat loss during construction would be small in comparative acreage to the region but may be locally significant. No important aquatic species are present on site. Impacts from construction activity to terrestrial habitat and the totality of the aquatic ecosystems would be limited and temporary; therefore, impacts during construction would be SMALL. Recovery of some species during operations is anticipated and impacts would be SMALL. (Ecology, 2007b) (NRC, 2008)

No known state or federal rare, threatened, or endangered plant species have been observed on the BBNPP site. Ten threatened and endangered species and species of special concern are known to have distribution in the area. Four important habitats, including wetlands, will be impacted (PDCNR, 2008a) (PDCNR, 2008b) (PPL, 2006) (Ecology, 1995) (Ecology, 2007a). Impact to wetlands and wetland buffer would require mitigation. Impacts would be MODERATE.

Based on a Phase Ia cultural and resource assessment and data base review at SSES, no confirmed listings of historical sites were identified. Therefore, adverse impacts are unlikely to this previously disturbed site. Impacts from construction and operations would be SMALL. (PHMC/BHP, 2001)

Construction employment impacts would be MODERATE (NRC, 2008), socioeconomic benefits from several hundred mining and construction and operation jobs as well as additional tax revenues would be associated with the coal mining (NRC, 1996). As a result, socioeconomic impacts would be MODERATE and beneficial.

As a result of increased safety technologies, accident impacts would be SMALL. Mining safety is not considered within this impact category.

As previously described, as a result of increased air emissions and public health risks, such as cancer and emphysema associated with those emissions, human health impacts during operation would be MODERATE and SMALL during construction because of best management practices to curb fugitive dust emissions (NRC, 2008).

Demographic characteristics of the area surrounding the BBNPP demonstrate that there are no significant numbers of minority or low-income populations represented in the vicinity; therefore, the environmental justice impact would be SMALL (NRC, 2008).

Summary (BBNPP ER 9.2.3.1.5)

The impacts for the operation of the coal-fired alternative would be SMALL, SMALL to MODERATE, and MODERATE. Water use and quality, terrestrial and aquatic ecology including wetlands, threatened and endangered species, cultural and historical resources, safety, and environmental justice impacts would be SMALL. Impacts to aesthetics would be SMALL to MODERATE and impacts to land use, air quality, waste management, human health, and socioeconomics would be MODERATE. Based on these impacts, the coal power generating facility would not be environmentally preferable to the BBNPP.

- **Natural Gas Generation (BBNPP ER 9.2.3.2)**

Most environmental impacts related to constructing natural gas-fired plants should be approximately the same for steam, gas-turbine, and combined-cycle plants. These impacts, in turn, generally will be similar to those of other large central generating stations. The environmental impacts of operating gas-fired plants are generally less than those of other fossil fuel technologies of equal capacity. The environmental impacts from natural gas generation alternatives were evaluated in the GEIS (NRC, 1996), draft GEIS for license renewal (NRC, 2008), and SSES Units 1 and 2 License Renewal Application (NRC, 2006).

Impacts from construction and operation of a natural gas-fired plant are summarized in Table 9.2-1, at the end of Section II.

Air Quality (BBNPP ER 9.2.3.2.1)

Natural gas is a relatively clean-burning fossil fuel. Also, because the heat recovery steam generator does not receive supplemental fuel, the combined-cycle operation is highly efficient (56% vs. 33% for the coal-fired alternative). Therefore, the gas-fired alternative would release similar types of emissions, but in lesser quantities than the coal-fired alternative. Control technology for gas-fired turbines focuses on the reduction of NOx emissions.
Human health effects are SMALL based on decreased air quality impacts. Natural gas technologies produce fewer pollutants than other fossil technologies, and SO_2, a contributor to acid rain, is not emitted at all (NRC, 1996). Air emissions were estimated for a natural gas-fired generation facility based on the emission factors contained in USEPA document AP-42 (USEPA, 1995). Emissions from the facility were based on a power generation capacity of 1,600 MW.

Current gas-powered electricity generation has a carbon footprint around half that of coal (approximately 500 gCO_2eq/kWh), because gas has a lower carbon content than coal. This is approximately 100 times higher than the carbon footprint of a nuclear power generation facility (approximately 5 gCO_2eq/kWh). Like coal-fired plants, gas plants could co-fire biomass to reduce carbon emissions in the future (POST, 2006).

The natural gas-fired generation facility assumes the use of a combined cycle gas turbine generator (GTG). Water injection is used to control nitrogen oxides emissions. Based on the emissions generated from a natural gas-fired facility, air impacts would be MODERATE.

Waste Management (BBNPP ER 9.2.3.2.2)

Construction wastes (land clearing and solid wastes) would be minimal and would be subject to regulatory control. Therefore, the impact of construction waste management would be SMALL (NRC, 2008).

Gas-fired generation would result in almost no waste generation, producing minor (if any) impacts. {Approximately 1,500 cubic ft of spent selective catalytic reduction catalyst would be generated per year for a 2,400 MW plant and would be less for a 1,600 MW plant. This waste would be shipped offsite for disposal. As a result, waste management impacts would be SMALL.

Economic Comparison (BBNPP ER 9.2.3.2.3)

DOE has estimated the cost of generating electricity from a gas-fired facility to be $0.047 per kWh. The projected cost associated with operating a new nuclear facility similar to BBNPP is in the range of $0.031 to $0.046 per kWh.

Although natural gas-fired generation is considered a competitive alternative to nuclear power generation, natural gas-fired generation is not considered to be environmentally preferable to the proposed action, as described in the following section. Therefore, as allowed in NUREG-1555, ESRP 9.2.3 (NRC, 2007), additional cost data, e.g., decommissioning costs, and fuel cost estimates, are not provided for alternatives that are not deemed to be environmentally preferable to the proposed action.

Other Impacts (BBNPP ER 9.2.3.2.4)

Construction of a 1,600 MW natural gas power generating facility could affect approximately 160 ac (65 ha) or 0.25 mi^2 (0.65 km^2) would be required for the facility and 12 ac (4.9 ha) or 0.02 mi^2 (0.05 km^2) for a pipeline that would be needed to connect to an existing line (PPL, 2006). Acreage does not include the gas well field (NRC, 2008). As a result, land use impacts would be SMALL during construction and operation of this type of facility.

According to the GEIS, consumptive water use is about the same for natural gas power generating facilities as for alternate power generating facilities. Water consumption is likely to be less for gas turbine power generating facilities (NRC, 1996). Potential impacts to aquatic biota through impingement and entrainment and increased water temperatures in receiving water bodies and water quality would be minimized but could be characterized as SMALL because of the natural gas power generating facility's use of a new cooling water system, dependent on the cooling system's design. Impacts from construction activities to surficial groundwater would be localized and SMALL. The groundwater would be expected to recover during operation; therefore, impacts to groundwater would be SMALL (PPL, 2006) (NRC, 2008). Impacts to surface water bodies are MODERATE during construction primarily because of loss of wetlands and wetland buffers. (NRC, 2008)

The BBNPP site is already aesthetically altered by the presence of the existing SSES Units 1 and 2 structures, and the gas-fired plant structures are smaller than the existing SSES structures. Gas-fired units would be about 100 ft tall, while the exhaust stacks would be at least 174 ft (53 m) tall as opposed to the current units' height of 540 ft (165 m) tall. A new Turbine Building and exhaust stacks would need to be constructed. Noise would be detectable offsite, but it is likely that the level would not be any greater than the existing plant noise; a closed cycle cooling alternative could also introduce plumes. As a result, aesthetic impacts would be SMALL (NRC, 2006) (NRC, 2008).

The BBNPP site would use a previously disturbed area near the SSES Units 1 and 2. Although permanent and/or temporary impacts during construction to wetlands and/or streams within the project footprint may occur, mitigation could be used to minimize impacts (NRC, 2006). Ecological resource impacts would, therefore, be SMALL.

Terrestrial habitat loss during construction is small in comparative acreage to the region but may be locally significant. No important aquatic species are present onsite. Impacts from construction activity to terrestrial habitat and aquatic ecosystems would be limited and temporary; therefore, impacts during construction would be SMALL. Recovery of some species during operation is anticipated and impacts would be SMALL. (Ecology, 2007b) (NRC, 2008)

No known state or federal rare, threatened, or endangered plant species have been observed on the BBNPP site. Ten threatened and endangered species and species of special concern are known to have distribution in the area. Four important habitats, including wetlands, will be impacted (PDCNR, 2008a) (PDCNR, 2008b) (PPL, 2006) (Ecology, 1995) (Ecology, 2007a). Impact to wetlands and wetland buffer would require mitigation. Impacts would be MODERATE.

Based on a Phase Ia cultural and resource assessment and database review at SSES, no confirmed listings of historical sites were identified. Therefore, adverse impacts are unlikely to this previously disturbed site. Therefore, impacts from construction and operations would be SMALL. (PHMC/BHP, 2001)

Construction employment impacts would be MODERATE (NRC, 2008). Socioeconomic benefits from approximately 88 construction and operations jobs, as well as additional tax revenues, would be associated with this alternative (PPL, 2006). As a result, socioeconomic impacts would be SMALL.

Because of increased safety technologies, accident impacts would be SMALL.
As previously mentioned, because of increased air emissions and public health risks, human health impacts would be MODERATE (PPL, 2006) and SMALL during construction because of best management practices to curb fugitive dust emissions (NRC, 2008).

Demographic characteristics of the area surrounding the BBNPP demonstrate that there are no significant numbers of minority or low-income populations represented in the vicinity; therefore, the environmental justice impact would be SMALL. (NRC, 2008)

<u>Summary (BBNPP ER 9.2.3.2.5)</u>

The majority of operations impacts for the natural gas-fired generator would be SMALL: land use, ecology, water use and quality, waste management, historical and cultural resources, environmental justice, aesthetics, socioeconomics, and safety. Categories with MODERATE impacts include air quality, human health and threatened and endangered resources due to impacts to wetlands. Because of these impacts, the natural gas power generating facility would not be environmentally preferable to the BBNPP.

- **Combination of Alternatives (BBNPP ER 9.2.3.3)**

BBNPP will have a baseload capacity of approximately {1,600 MW.} Any alternative or combination of alternatives would be required to generate the same baseload capacity. Because of the intermittent nature of the resources and the lack of cost-effective technologies, wind and solar energies are not sufficient on their own to generate the equivalent baseload capacity or output of BBNPP, as discussed under Wind and Solar Power, above. As noted in Coal-Fired Generation and Natural Gas Generation, fossil fuel-fired technology generates baseload capacity, but the associated environmental impacts are greater than for a nuclear facility.
A combination of alternatives may be possible but should be sufficiently complete, competitive, and viable to provide NRC with appropriate comparisons to the proposed nuclear plant.

Determination of Alternatives (BBNPP ER 9.2.3.3.1)

Many possible combinations of alternative power generation sources could be used to satisfy the baseload capacity requirements of the BBNPP facility. Some of these combinations include renewable sources, such as wind and solar, although wind and solar do not, by themselves, provide a reasonable alternative energy source to the baseload power to be produced by the BBNPP facility. In combination with fossil fuel-fired power generation, however, wind and solar may be a reasonable alternative to nuclear energy produced by the BBNPP facility.

The ROI/primary market area utilizes a diversity of fuel sources for baseload power generation, including the alternatives identified in this section as a combination alternative to the baseload power to be provided by the BBNPP. A generation portfolio of diverse fuel sources reduces the risk to system reliability from the availability of individual fuels, the transportation of individual fuels, and the impact of fuel price variations and consequent generation loading patterns.

The BBNPP will operate as a baseload, merchant independent power producer. The power produced will be sold on the wholesale market without specific consideration to supplying a traditional service area or satisfying a reserve margin objective. The ability to generate baseload power in a consistent, predictable manner meets the business objectives for the BBNPP. Therefore, when examining combinations of alternatives, the ability to consistently generate baseload power must be a determining factor when analyzing the suitability of the combination. This section reviews the ability of the combination alternative to have the capacity to generate baseload power equivalent to BBNPP.

When examining a combination of alternatives that would meet business objectives similarly to that for the BBNPP, any combination that includes a renewable power source (either all or part of the capacity of the BBNPP) must be combined with a fossil-fueled facility equivalent to the generating capacity of the BBNPP. This combination would allow the fossil-fueled portion of the combination alternative to produce the needed power if the renewable resource is unavailable and to be displaced when the renewable resource is available.

For example, if the renewable portion is provided by some amount of wind generation and that resource became available, then the output of the fossil fueled generation portion of the combination alternative could be lowered to offset the increased generation from the renewable portion. This facility, or facilities, would satisfy business objectives of the BBNPP facility in that it would be capable of providing the requisite baseload power regardless of the availability of the renewable power source.

Coal and natural gas power generating facilities have been determined to have environmental impacts that are equivalent to or greater than the impacts of the BBNPP. Based on the comparative impacts of these two technologies, as shown in Table 9.2-1, it can be concluded that a natural gas power generating facility would have less of an environmental impact than a comparably sized coal power generating facility. In addition, the operating characteristics of natural gas power generation are more amenable to the kind of load changes that may result from inclusion of renewable generation, such that the baseload generation output of 1,600 MW is maintained.

"Clean Coal" power plant technology could decrease the air pollution impacts associated with burning coal for power. Demonstration projects show that clean coal programs reduce NOx, SOx, and particulate emissions; however, the environmental impacts from burning coal using these technologies, if proven, will still be greater than the impacts from natural gas (NETL, 2001). Therefore, for the purpose of examining the impacts from a combination of alternatives to the BBNPP, a natural gas power baseload generating facility equivalent to the BBNPP was used in the environmental analysis of combination alternatives.

The analysis accounts for the reduction in environmental impacts from a gas-fired facility when generation from the facility is displaced by the renewable resource. Additionally, the impact associated with the combined-cycle natural gas-fired unit is based on the gas fired generation impact assumptions discussed under Natural Gas Generation. Additionally, the renewable portion of the combination alternative would be any combination of renewable technologies that could produce power equal to or less than the BBNPP when such resources were available.

This combination of renewable energy and natural gas-fired generation represents a potentially viable mix of non-nuclear alternative energy sources. Many types of alternatives can be used to supplement wind energy, notably solar power. PV cells are another source of solar power that would complement wind power by using the sun during the day to produce energy while wind turbines use windy and stormy conditions to generate power. Wind and solar facilities in combination with fossil fuel facilities (coal, petroleum) could also be used to generate baseload power.

However, wind and solar facilities in combination with fossil fuel facilities would have equivalent or greater environmental impacts relative to a new nuclear facility at the BBNPP site. Similarly, wind and solar facilities in combination with fossil fuel facilities would have costs higher than a new nuclear facility at the BBNPP site. Therefore, wind and solar facilities in combination with fossil fuel facilities are not competitive with a new nuclear unit at the BBNPP site.

<u>Environmental Impacts (BBNPP ER 9.2.3.3.2)</u>

The environmental impacts associated with a gas-fired power generation facility sized to produce power equivalent to the BBNPP have already been described in previous sections. Depending on the level of potential renewable output included in the combination alternative, the level of impact of the gas-fired portion would be comparably lower during periods that the renewable resource is available. If the renewable portion of the combination alternative were not enough to displace all of the power produced by the natural gas power generation, then there would be some level of impact associated with the natural gas power generating facility. Alternately, if the renewable portion of the combination alternative were enough to fully displace the output of the natural gas portion, then when the renewable resource is available, the output of the natural gas power generating facility could be removed, thereby eliminating its operational impacts.

The environmental impacts associated with solar and wind power generating facilities are discussed under Wind and Solar Power, above. Whereas the natural gas plant and solar arrays could potentially be built on the BBNPP site, the level of wind, as previously discussed, is not sufficient for this technology. The wind facility, therefore, would need to be located off site but within the ROI. If this technology combination were deemed to be feasible, then potential locations within the ROI could be evaluated. In comparing the environmental impacts of the combinations, existing information was used for the previously determined gas-fired generation in conjunction with available data for solar and wind technologies. Because a location within the ROI has not been selected, information regarding many of the impact categories could not be determined.

Categories of impacts that would be SMALL include waste management and accidents, and categories of impacts that would be MODERATE include air quality, water use and quality, socioeconomics, human health, and environmental justice. Categories with SMALL to LARGE impacts include land use, ecology, historical and cultural resources, and threatened and endangered resources. It should be noted, however, that the natural gas power generating facility alone has larger impacts than the BBNPP. The greater the potential output of the renewable portion of the combination alternative, the closer the impacts would approach the level of impacts associated with the BBNPP.

The combination of wind and/or solar power generating facilities with a natural gas power generating facility would have environmental impacts equal to or greater than the BBNPP. When the renewable resource is not available, the environmental impacts would be greater than the BBNPP. Therefore, the most favorable combination of energy alternatives is not environmentally preferable to the BBNPP.

<u>Economic Comparison (BBNPP ER 9.2.3.3.3)</u>

As noted earlier, the combination alternative must generate power equivalent to the capacity of the BBNPP. DOE has estimated the cost of generating electricity from a gas-fired facility ($0.047 per kWh), a wind facility ($0.057 per kWh), and a solar facility ($0.04 to $0.05 per kWh) (DOE, 2002). The cost for a natural gas-fired facility in combination with a renewable facility would increase, because the facility would not be operating at full availability when it is displaced by the renewable resource.

As a result, the capital costs and fixed operating costs of the natural gas facility would be spread across fewer kWh from the gas facility, thereby increasing its cost per kWh. The projected cost associated with operating a new nuclear facility similar to the BBNPP is in the range of $0.031 to $0.046 per kWh. The projected costs associated with forms of generation other than from a nuclear unit would be higher. Therefore, the cost associated with the operation of the combination alternative would not be competitive with the BBNPP.

Summary (BBNPP ER 9.2.3.3.4)

Because the combination alternative is not considered to be a competitive alternative to nuclear power generation, this combination is not considered to be environmentally preferable to the proposed action as described in the following section. Therefore, as allowed in NUREG-1555, ESRP 9.2.3 (NRC, 2007), additional cost data, e.g., decommissioning costs and fuel cost estimates, are not provided for alternatives that are not deemed to be environmentally preferable to the proposed action.

The combination of wind and natural gas power generation may have a lower land-use impact than the BBNPP. However, as previously discussed, the wind farm could not be co-located with the natural gas power generation facility at the BBNPP site. Since the natural gas power generation facility would be designed to deliver the full 1,600 MW during periods when any or all of wind power generation is unavailable, the environmental impact of this combination would be equivalent to or greater than natural gas power generation alone, and greater than the impact of the BBNPP.

The combination of solar power and natural gas power generation would have a greater environmental impact than the BBNPP, primarily because of the large land area required for the solar facility. Therefore, this combination, would have equivalent or greater environmental impacts than a nuclear power generating facility at the BBNPP site, and land requirements would be substantially larger.

Neither a wind power generation facility in combination with a natural gas power generating facility nor a solar power generation facility in combination with a natural gas power generating facility is an environmentally preferable alternative to the BBNPP.

- **Conclusion (BBNPP ER 9.2.3.4)**

Neither a power generating facility fueled by coal, nor one fueled by natural gas, nor a combination of alternatives, including wind and/or solar power generating facilities, would provide an appreciable reduction in overall environmental impacts relative to the BBNPP. Furthermore, each of these types of alternatives, with the possible exception of the combination alternative, would entail a significantly greater environmental impact on air quality than would a nuclear power generating facility. To achieve a SMALL air quality impact in the combination alternative by using larger amounts of wind or solar generation, a MODERATE to LARGE impact on land use would result. Therefore, PPL concludes that neither a power generating facility fueled by coal, nor one fueled by natural gas, nor a combination of alternatives, would be environmentally preferable to a nuclear power generating facility at the BBNPP site. Furthermore, these alternatives would have higher economic costs, and therefore, would also not be economically preferable to a nuclear power generating facility.

INSERT TABLE 9.2-1

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