Sustainable Energy Parks on Mine-Scarred Lands in Appalachia

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Table of Contents

Acknowledgements i
Table of Contents ii
Appendices v
List of Figures vi
List of Tables viii
Executive Summary ix
Chapter 1 - Project Description 1
Background 1
Project Location 2
Alternative Energy Types Defined 3
Biofuels 3
Wind 4
Solar 4
Geothermal 4
Chapter 2 - Project Purpose 5
Objective 5
Tasks 5
Deliverables 5
EPA's Strategic Objectives 6
Appalachian Regional Commission Strategic Objectives 6
Performance Measurements: Outcomes and Outputs 6
Outcomes 6
Outputs 7
Chapter 3 - Methods and Results 9
Site Identification Process 9
Mining Dataset Creation and Initial Analysis 9
Mine Lands Evaluated 9
Enhanced Site Selection Criteria and Analysis 26
GIS Model Development 32
Land Ownership Considerations 33
Chapter 4 - Identification of Potential Sustainable Energy Park Locations 37
Portfolio of Candidate Sustainable Energy Park Sites 41
Chapter 5 - Prioritization Tool 46
Purpose 46
Goals and Objectives 46
Background 46

Prioritization Tool Use 48
Chapter 6 - Community Engagement, Education, and Training 50
Conceptual Drawing 50
Project Fact Sheet 51
Project Flyer 51
Meetings with Local Government 51
Presentations 51
Meetings 51
WVU Extension Professional Development Days Short Course 52
K-6 Report 52
Web Portal 52
Chapter 7 - Selection of a Pilot Sustainable Energy Park Site 53
Request for Proposals 53
RFP Announcement 53
Coordination with Land Use Master Plans 53
Community Meetings 54
Proposal Development Briefings and Workshops 54
Briefings 54
Workshops 54
Administer Participatory Planning with Officials and Experts 54
Review and Selection of Pilot Site 55
1. Reviewers 55
2. Proposals Received 55
3. Disseminate Proposals to Reviewers 57
4. Rank and Select Potential Projects 57
5. Submit Recommended Project to USEPA for Consideration 58
6. USEPA Confirms Selected Community 58
7. Applicants Notified of Results 58
Chapter 8 - Comprehensive Development Plan 59
Site Assessment 59
General Overview 59
Soils 60
Hydrology 63
Vegetation 66
GIS Analysis of Site Conditions 68
Process for the Creation of Comprehensive Development Plan 70
Business Planning for Sustainable Energy Park Development 73

Market and Economic Analysis for Biomass 73
Market and Economic Analysis for Solar Industry 77
Market and Economic Analysis for Wind Energy 82
SEP Marketing Plan and Activities 89
Project Marketing Activities: Presentations and Meetings 89
Site-specific Market and Environmental Studies 91
Comprehensive Land Use Master Plan 110
Development Phasing 113
Chapter 9 -Conclusions 114
Lessons Learned 115
Lesson 1: The definition and use of the term Mine-scarred land is significant 115
Lesson 2: Stakeholder Engagement is Critical 115
Lesson 3: Land Ownership/Control Considerations 115
Lesson 4: Think Local Energy End Users 115
Results Summary 116
Leveraged Funding 117
Future of the Project 117
Appendices 118
References 119

Appendices

Appendix A – Soil Sample Results
Appendix B – Data Source Methodology
Appendix C – Indicators and Data Sources
Appendix D – Portfolio of Candidate Sites
Appendix E – Prioritization Tool and Handbook
Appendix F – SEP Fact Sheet
Appendix G – Project Flyer
Appendix H – Request for Proposals
Appendix I – Visualization Presentation
Appendix J – Feedback Loop Exercise
Appendix K – Community Meeting Presentation
Appendix L – Comprehensive Report on Biofuels
Appendix M – SEP Showcase Video
Appendix N – Comprehensive Land Use Master Plan

List of Figures

Figure 1. Map depicting preliminary top 11 aggregated surface mine sites. 10
Figure 2. Selected large tract mine sites with 0-5% slope. 11
Figure 3. Land use cover for the International Coal Group (ICG) site, Mingo County, West Virginia. . 12
Figure 4. Land use cover for the Jacks Branch site, Kanawha County, West Virginia..... 13
Figure 5. Land use cover for the Elk Run site, Boone County, West Virginia. 14
Figure 6. Land use cover for the Mountain View site, Boone County, West Virginia. 15
Figure 7. Land use cover for the Independence site, Logan and Boone Counties, West Virginia. 16
Figure 8. Land use cover for the Hobet site, Boone County, West Virginia. 17
Figure 9. Land use cover for the Coal-Mac site, Mingo and Logan Counties, West Virginia. 18
Figure 10. Land use cover for the Alex site, Clay and Nicholas Counties, West Virginia. 19
Figure 11. Aerial imagery (left) and high resolution land cover (right) of Raleigh County, West Virginia. 20
Figure 12. Digitized southern West Virginia coalfields. 21
Figure 13. LiDAR images used to create terrain models..... 21
Figure 14. Reclaimed mine area suitable for biofuel production at the Coal-Mac site in Logan County, West Virginia. 22
Figure 15. Portion of the Coal-Mac site in Logan County, West Virginia that is currently undergoing mining. 23
Figure 16. Plateau area in reclaimed portion of the Coal-Mac site in Logan County, West Virginia. . 23
Figure 17. Locations of selected surface mine sites in West Virginia. 24
Figure 18. SEP data flow schematic. 29
Figure 19. Potential SEPs locations in relationship to existing infrastructure in West Virginia. 29
Figure 20. A zoomed- in view of the interactive map which depicts the additional information. 30
Figure 21. Proposed TrAIL transmission line. 31
Figure 22. Representation of 3D models incorporated into a visual presentation of a possible future SEP. 32
Figure 23. Example map depicting active (pink areas) versus bond-released (green areas) sites in West Virginia..... 34
Figure 24. Number of potential SEP sites per county in West Virginia, based on a minimum of 100 surface mined acres. 37
Figure 25. Methodology for simplifying mine features. 38
Figure 26. Histogram distribution of site acres..... 39
Figure 27. Total area of sites by county considered to be suitable for SEPs based on site selection criteria. 39
Figure 28. Potential SEP sites in Nicholas County, West Virginia. 40
Figure 29. Example of potential sites near Morgantown, West Virginia..... 40
Figure 30. Example image of SEP conceptual drawing. 50
Figure 31. Proposed SEP site in Grant County, West Virginia. 55
Figure 32. Detailed view of proposed SEP site in Grant County, West Virginia. 56
Figure 33. Proposed SEP site in McDowell County, West Virginia. 56
Figure 34. Detailed view of proposed SEP site in McDowell County, West Virginia. 57
Figure 35. Boundary of potential SEP site in McDowell County, West Virginia. 59
Figure 36. Soil sample collection location A, Indian Ridge site, McDowell County, West Virginia..... 61
Figure 37. Soil sample collection location B, Indian Ridge site, McDowell County, West Virginia. 62
Figure 38. Water sample collection location A, at Indian Ridge site, McDowell County, West Virginia; area view (left), and close-up view (right). 65
Figure 39. Water sample collection location B at Indian Ridge site, McDowell County, West Virginia; area view (left), and close-up view (right). 65
Figure 42. Overall elevation conditions at the proposed SEP site, Indian Ridge, McDowell County, West Virginia..... 68

Figure 43. Land cover map of the proposed SEP site, Indian Ridge, McDowell County, West Virginia. 69
Figure 44. Slope in degrees at proposed SEP site, Indian Ridge, McDowell County, West Virginia... 69
Figure 45. Slope aspect at the proposed SEP site, Indian Ridge, McDowell County, West Virginia... 70
Figure 46. Working at the 4-H Camp at Glen Fork in Wyoming County, West Virginia with students from Wyoming and McDowell County High Schools. 73
Figure 47. U.S. electricity generation by non-hydro renewable resources (billion kWh). 84
Figure 48. Wind generation in Maryland, Ohio, Pennsylvania and West Virginia. 86
Figure 49. 2012 West Virginia Brownfields Conference Agenda..... 89
Figure 50. Planting of biomass crops at the Coal-Mac site, Holden, West Virginia. 93
Figure 51. Biomass crop at the Coal-Mac site after 1 year, Holden, West Virginia. 94
Figure 52. Switchgrass crop, 4-years after planting at the Alton site, Upshur County, West Virginia. 95
Figure 53. Proposed solar array location in proximity to area power lines for a surface mine site in McDowell County, West Virginia. 97
Figure 54. Expected monthly output for a 650 kWDC solar array system (kWh). 99
Figure 55. Expected monthly output for a 2 MW solar array system (kWh). 100
Figure 56. Modeled turbine layout at the Grant County, West Virginia site. 106
Figure 57. Monthly estimated energy output at 7.7 m/s and 7.3 m/s. 107
Figure 58. Land Use Master Plan for the Indian Ridge Industrial Park, McDowell County, West Virginia. 111
Figure 59. Regional Land Use Master Plan shows the entire Indian Ridge site owned by McDowell County EDA. 112
Figure 60. Detail view of three-dimensional digital site model including the expressways, integrated switchgrass and solar facilities (view from southeast with FCI-McDowell in the foreground). 113

List of Tables

Table 1. Mine site soil sample location descriptions. 25
Table 2. Summary of property owners of preliminary top 11 areas considered for SEPs. 34
Table 3. Area statistics for resulting features or sites. 38
Table 4. Excerpt showing 300 of the 612 sites identified in the SEP portfolio. 41
Table 5. Wind screening criteria and market values tab within the Prioritization Tool. 47
Table 6. Solar screening criteria and market values tab within the Prioritization Tool. 47
Table 7. Biofuels screening criteria and market values tab within the Prioritization Tool. 47
Table 8. Biofuel Outputs tab within the Prioritization Tool. 48
Table 9. Solar Outputs tab within the Prioritization Tool. 48
Table 10. Wind Outputs tab within the Prioritization Tool. 49
Table 11. Results of surface soil samples collected at the Indian Ridge site, McDowell County, West Virginia. 62
Table 12. Analytical results of surface water samples collected from the Indian Ridge site, McDowell County, West Virginia. 65
Table 13. AEP biomass supply specifications by plant (as of February 2010). 74
Table 14. Switchgrass production costs. 75
Table 15. Range of prices for regional SREC markets ($/MWh). 80
Table 16. Installed wind capacity and generation in regional states as of the end of 2011. 83
Table 17. Number of wind projects included in state portfolio standard accounting. 87
Table 18. Soil samples collected at the Coal-Mac site are indicative of freshly placed mine soils in southern West Virginia. 96
Table 19. Solar insolation in select cities of the United States. 99
Table 20. Commercial net metering arrangement results. 102
Table 21. IRR for third-party purchase scenario. 103
Table 22. Wind facility SAM results – key financial variables. 108

Executive Summary

Production of alternative energy on Appalachian mine-scarred lands has the potential to change the economic and environmental landscape of small communities over a large region. Researchers at West Virginia University (WVU) and Marshall University (MU) completed a joint effort with the United States Environmental Protection Agency (USEPA) Region III to assist communities in identifying and realizing opportunities for using mine-scarred lands as alternative energy production sites. Project researchers refer to these sites as Sustainable Energy Parks (SEPs). The development of SEPs in former coalfield communities can take advantage of existing energy and industrial transportation infrastructure, large, contiguous tracts of land, a labor force that is familiar with processing natural resources, and a location suitable for the production of a range of alternative energy resources.

Researchers created a framework by which communities, regional development authorities, state agencies, and developers can evaluate sites, develop plans, and attract financing to convert former surface mine sites into new opportunities for continued cash flow into the host communities. The framework consists of a portfolio of candidate SEPs, a Prioritization Tool and Handbook to assist in the evaluation of the identified sites. It also includes new sites of interest and a Comprehensive Development Plan for a pilot SEP.

The research efforts produced an inventory of 612 mine-scarred land sites throughout West Virginia that present viable options for the development of SEPs. The researchers identified a pilot site, Indian Ridge, in McDowell County, West Virginia, and implemented assessment, planning, and analysis for the development of a SEP on the former surface mined location.

The Federal Correction Institution (FCI) McDowell County site, located in southern West Virginia, has approximately 224 acres that are suitable for the development of biomass crops. This site, once planted and harvested, could produce approximately 1,344 tons per year of biofuel. This fuel could then be sold on the market where it could net approximately $80,000 per year based on 2012 rates. Planting and maintenance costs would impact this number. The biofuel could be used as a fuel source to power the boilers at the nearby federal prison or could be used for pelletizing.

A Comprehensive Plan of the McDowell County site was produced. The plan includes a detailed Land Use Master Plan for the implementation of a SEP. Researchers coordinated with the McDowell County Economic Development Authority to develop these plans. The Comprehensive Plan includes an evaluation of site specific environmental conditions of the former surface mine at FTP-McDowell in McDowell County, West Virginia.

The concept and redevelopment plans of this McDowell County pilot SEP site were showcased at the 2012 West Virginia State Brownfields Conference at Glade Springs Resort in Beckley, West Virginia on September 5, 2012. The stakeholder groups at the Showcase included local citizens and officials, economic development agencies, adjacent property owners, coal company representatives, renewable energy industry representatives, and potential investors. The SEP Pilot Site Comprehensive Plan is under consideration for implementation by the site's owner, McDowell County Economic Development Authority.

The outputs and outcomes realized from this project aid in land and community revitalization efforts in Appalachia's coalfields and other historic mining regions in the United States. They help fulfill goals of the USEPA Mine-Scarred Land Initiative to reduce greenhouse gas emissions, protect water quality, restore land, and to clean up and revitalize brownfields. They also help to meet the economic and energy development goals of the Appalachian Regional Commission.

Based on the 11,782 acres that meet all of the criteria established for switchgrass production within the 612 candidate SEP sites identified, an average of 649 tons per year could be harvested with a net worth of approximately $2,221,764 per year based on 2012 rates.

The McDowell County site has a wind resource potential of 4.6m/s at 80m. While this rating makes the site nonviable for medium to high-speed turbines, the site may still be considered a candidate dependent on the availability of turbines capable of utilizing low-speed wind. Additional research would be needed to obtain a more site-specific measurement of the actual wind speed. If turbines are placed on the site, the direct economic impacts of the facility will be small following construction.

The McDowell County site fares well when evaluated against EPA's Re-Powering America's Land Initiative's pre-screening site characteristics. The site receives more than 3.5 kwh/$M^{2/day}$ of solar insolation and much of the acreage is located less than one mile from a graded road. The site also fares well with other screening characteristics such as load assessment. However, the site does not fare well with regards to financial screening due to the lack of utility or other state-based incentives for PV. Based on this research and the Prioritization Tool developed, of our 612 sites, we determined that 109 sites had potential for biofuels development, 4 sites had potential for solar development, and 1 site had the potential for wind development.

Chapter 1 - Project Description

Background

Small rural communities that depend on coal mining often wonder what will sustain their economies after the coal is gone. There is no single answer, but one future industry for these communities may be alternative energy production such as cellulose based ethanol and/or pelletized biofuels, wind, geothermal, and/or solar power generation. These energy sources may never generate the amount of revenues that come from coal mining, but they are more environmentally benign and provide a steady source of needed revenue for communities. Researchers at West Virginia University (WVU) in collaboration with Marshall University (MU) have utilized brownfields site research and technical assistance to help these underserved coalfield communities realize opportunities for turning mine-scarred lands into productive alternative energy sites which we call Sustainable Energy Parks (SEPs).

On January 11, 2002, President George W. Bush signed into law the Small Business Liability Relief and Brownfields Revitalization Act (H. Res 2869, 2002). This brownfields law expanded the definition of brownfields to include *mine-scarred lands*, making these properties eligible for the benefits of the United States Environmental Protection Agency (USEPA) Brownfields Program.

Mine-scarred lands are lands, associated waters, and surrounding watersheds where extraction, beneficiation, or processing of ores and minerals (including coal) has occurred. Abandoned mining sites composed of hard rock and coal mines across the United States are located on both public and private land and involve complex economic, social, and environmental issues. Mine-scarred lands have become a persistent problem in many communities due to the economic and environmental challenges of cleaning up and reusing them. The impacts of economic distress are felt by many former mining communities as they transition from an extraction industry to new enterprises. There is often limited infrastructure or land suitable for development. In addition, the blighting influence of mine-scarred lands may deter new investment.

Abandoned mine lands are often located in economically depressed areas with communities that once thrived during the mining booms but now comprise very few residents or opportunities. These areas are in need of new economic opportunities to replace the jobs once provided by the mining industry. The issues related to formerly mined sites make it difficult for communities to attract industry or tourism. Mined sites often have sparse or scrubby vegetation, stagnant or polluted water, and debris. The appearance of mined sites can depress land value, detracting from the tax base (Abandoned Mine Reclamation Clearinghouse, 2012).

Acid Mine Drainage (AMD) occurs when water comes in contact with mining wastes during and after operations. The resulting acidic water seeps through and flows out of abandoned mines long after they are closed. AMD often discharges directly into streams, killing vegetation, degrading aquatic ecosystems, threatening fish and wildlife, and posing a threat to public water supplies. Stockpiled waste rock and tailings pose a serious threat to the health of ecosystems. Wastes from mining operations are left behind in large “gob” piles, or waste dumps, and often contribute to metal loading in streams and rivers. Stored chemicals and leaking containers left behind when mines close often pose additional dangers at these sites. Containers can be damaged or corroded, exposing dangerous contents. Open shafts, rotting support structures, equipment, and open pits found at abandoned mine sites pose a health and safety threat to local residents.

Post-mining lands are typically graded, soil replaced, and seeded with cool season grasses. Without regular management a natural succession of shrubs, trees, and scrub vegetation invade and become

established. Planning and management of these lands will be necessary in establishing SEPs. In this study, the economic viability of growing biofuels and implementing other energy sources including wind, solar, and geothermal energy are considered in conjunction with mine land location, terrain, transportation, local work force, and other factors.

Production of alternative energy on Appalachian mine-scarred lands has the potential to change the economic and environmental landscape of small communities over a large region. The research team created a framework to evaluate former surface mines sites in West Virginia to illustrate the development of comprehensive plans, and showcase the potential of converting former surface coal mines into sustainable green energy industries. These research project components serve to attract project financing, economic development and an alternative source of revenue to the communities from which these energy resources are being extracted. The framework can be used by communities, regional development authorities, state agencies, and developers to explore the feasibility of reusing mine-scarred lands for alternative energy sources.

Project Location

Appalachia is an approximately 200,000 square mile region that follows the spine of the Appalachian Mountains from southern New York to northern Mississippi. It includes all of West Virginia and parts of 12 other states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. Historically, the poverty rate in the Appalachian region is higher than that of the rest of the nation. In 2000, the Appalachian and West Virginia poverty rates were 110% and 144% that of the nation, respectively. West Virginia's poverty rate was the second highest among all thirteen states in the region. About 23 million people live in the 410 counties of the Appalachian Region, including all 55 counties of West Virginia (Appalachian Regional Commission, n.d.). The population of West Virginia is approximately 1.8 million with a population density of approximately 75 people per square mile. In many areas of the state, population densities of less than 10 people per square mile exist. Forty-two percent of the region's population lives in rural communities, compared with 20 percent of the national population. The region's economic fortunes have historically been connected to the extraction of natural resources and manufacturing. While coal mining remains an important industry in the West Virginia economy, it is no longer the major provider of jobs it once was (U.S. Census, 2013).

In addition, recent research has indicated that residents in West Virginia coal communities are suffering the legacy of past economic activity. Project researchers have found that residents in coalfield counties face a greater risk of early death and of suffering from heart, lung, and kidney disease. These studies took into account age, obesity, smoking, and diet and still found coal-producing counties with higher rates of death and disease (Hendryx, 2009).

Unlike all other regions of the United States, current and persistent economic distress within the central Appalachian region has been associated with employment in the mining industry, particularly coal mining. In terms of the relationship between mining and distress in central Appalachia, it is perhaps most useful to understand this relationship in the context of the changing nature of employment in the coal mining industry over time. In the past, many central Appalachian communities were largely dependent upon coal mining for income and employment. In some instances, employment in mining offered relatively high wages, though boom and bust cycles often affected the dependability of jobs within the industry. Employment in mining throughout much of central Appalachia was often marked by uncertainty, as mines would open and close or layoff large numbers of workers in relation to national and global trends in energy costs and needs, as well as in relation to increasing mechanization within the mining industry itself. In short, low levels of employment in manufacturing and professional services, along with a somewhat continued

dependency on the relatively few coal mining jobs in the region, have led to central Appalachian counties remaining distressed.

The impact of bringing the energy production and processing industry back to coalfield communities would be significant. Coalfield communities have suffered greatly from the loss of the major, and sometimes only, employer in their area. The development of SEPs in former coalfield communities can take advantage of infrastructure associated with existing energy and industrial transportation, large contiguous tracts of land, and a labor force that is familiar with processing natural resources. According to some estimates, renewable energy sources generate four times as many new jobs per megawatt of installed capacity as natural gas and 40% more jobs per dollar invested than coal. Thus the job development opportunities in these areas are potentially substantial (Appalachian Regional Commission, 2006).

Alternative Energy Types Defined

Biofuels

Biofuels can be utilized by co-firing in boilers with coal, pelletizing for direct combustion, or converted into liquid fuels using three basic pathways: Corn-based ethanol, oilseed-based biodiesel, or cellulosic ethanol made from wood waste or switchgrass. Both corn-based ethanol and oilseed-based biodiesel compete with food production and prime agricultural land. Corn-based ethanol consumed 20% of U.S. corn production last year to produce five billion gallons, or 1%, of U.S. petroleum consumption. If 100% of the U.S. corn crop were used for ethanol it would only replace 7% of our petroleum consumption. This process drives up the price of food, particularly corn-fed meat sources. It is becoming clear that for biofuels to be sustainable, we need to examine other alternatives.

Switchgrass has many advantages for either solid or liquid biofuel production, including: 1) It tolerates poor soils and drought; and 2) It is a perennial that regrows from the roots after harvesting. Moreover, switchgrass plantations can be established in a much shorter time period and at less cost than forests. Unlike corn-based ethanol, switchgrass ethanol returns 5.5 times more energy than is input into the process. The large root system of switchgrass also provides a high evapotranspiration rate, facilitating infiltration of precipitation and potentially reducing polluted runoff when planted on mined land. It is established using conventional planting techniques and harvested with common farm baling equipment. In addition, switchgrass produces more biomass than other grasses and provides enhanced wildlife habitat for species such as deer, turkey, and songbirds.

West Virginia has many advantages for growing switchgrass for biofuel. The state is close to major markets and has abundant water supplies for ethanol processing. West Virginia receives abundant rainfall and has a long, warm growing season. The state receives an average rainfall of 45-55 inches per year, which is much higher than many mid-western states that might receive 15-30 inches per year.

Large, contiguous blocks of land are most attractive for biomass production. West Virginia has large blocks of abandoned and active mined land, approximately 500,000 acres, potentially available for switchgrass production. For example, a surface mine site in Logan County is about 12,000 acres (19 mi^2) and another surface mine site in Boone County is about 8,000 acres (12 mi^2). Many other mines are between 3,000 and 5,000 acres. A significant portion of those mines have existing road networks and terrain characteristics that would be suitable for switchgrass cultivation. A switchgrass pelletizing and cellulosic ethanol production industry can provide a vibrant economy for local communities in decline post-mining.

In addition to the mine-scarred land, other associated brownfield sites include adjacent coal cleaning plants and loading facilities. These sites are often along major transportation corridors such as rivers, highways and railways. Transportation of ethanol by pipeline is difficult; therefore truck, rail, and barge will most likely be used if the material is moved off site.

Wind

Wind energy is captured by wind turbines with propeller-like blades mounted on a tower. The force of the wind causes the rotor to spin and the turning shaft spins a turbine to generate electricity. Wind technology is scalable; based on site conditions, different turbine designs can be used to meet different electricity needs. Utility scale projects use large turbines at the megawatt (MW) or multi-MW scale on sites with the greatest wind resource and acreage availability. Electricity generated is typically exported to the grid.

Solar

Solar power converts sunlight into electricity. Utility-scale solar energy projects require access to large, open sites. The size of many of the former surface mined land in Appalachia would allow for large solar arrays to be developed at a single property.

Geothermal

Geothermal energy technologies use the heat of the earth for direct-use applications, geothermal heat pumps, and electrical power production. In October 2010, an analysis by Southern Methodist University (SMU), funded by grants from Google.org, found West Virginia's geothermal generation potential to be the greatest in the East Coast at 18,890 megawatts (Blackwell, *et al*., 2011).

Chapter 2 - Project Purpose

Objective

The primary objective of this project is to ***create a framework for developing Sustainable Energy Park (SEP) opportunities on former mined lands in Appalachia that can be transferred to other communities facing similar challenges posed by mine-scarred land redevelopment.*** Consideration has been given to the potential of alternative energy generation including biomass, wind, solar and geothermal production.

Using the SEP framework, researchers identified mine-scarred lands in Appalachia suitable for redevelopment into alternative energy production sites that would:

- Generate local economic growth,
- decrease or offset greenhouse gases through carbon sequestration, and
- promote the development of renewable energy technologies.

Tasks

Eleven specific objectives, stated in terms of tasks, were identified to complete this project and are listed below.

1. Identify large tracts of potentially usable mine-scarred land.
2. Develop site selection criteria.
3. Develop a Portfolio of Candidate SEPs.
4. Develop a site Prioritization Tool.
5. Perform site specific market studies.
6. Develop and release a Request for Proposals.
7. Engage, educate, and train communities.
8. Review proposals and select one community.
9. Develop Comprehensive Development Plan.
10. Showcase a Pilot SEP Project.
11. Project management.

Deliverables

<u>Portfolio of Candidate SEPs: Tasks 1-3</u>

The identification of large tracts of mine lands (Task 1), including evaluating the characteristics of those tracts was utilized to develop a potential SEP site selection criteria. The site section criteria (Task 2) were used to develop an Inventory of Potential SEP sites in West Virginia (Task 3).

<u>Prioritization Tool and Handbook: Tasks 3- 5</u>

Researchers developed a site selection criteria matrix, the Prioritization Tool, in which production estimates of biofuels, wind turbines, and solar panels on mined lands can be calculated. A Prioritization Tool Handbook was also developed to assist interested communities and investors in evaluating potential SEP sites for alternative energy development.

<u>Selection of a Pilot Sustainable Energy Park Site and Education of Coalfield Stakeholders: Tasks 6-8</u>

A Request for Proposals (RFP) was developed to identify and competitively select an appropriate candidate site for a pilot SEP. As a part of this process, various stakeholder groups were identified and informed about SEPs and the opportunities they present.

<u>Comprehensive Development Plan for the Indian Ridge Site in McDowell County, WV: Tasks 5, 7, 9</u>

Community meetings, site analysis, and an evaluation of alternative energy markets were utilized to create a Comprehensive Development Plan for the competitively selected SEP pilot site in McDowell County West Virginia.

Sustainable Energy Park Showcase: Task 10

The Sustainable Energy Park Showcase Event was held on September 5, 2012 at Glade Springs Resort and Conference Center in Beckley, West Virginia. Titled the "Renewable Energy Showcase," it was a major component of the 2012 West Virginia Brownfields Conference with over 175 participants.

EPA's Strategic Objectives

The outcomes realized from this proposed project fulfill goals of the Mine-scarred Land Initiative and aid in land and community revitalization. Specifically, this project benefits several areas of EPA's strategic plan, including:

1. ***Objective 1.5: Reduce Greenhouse Gas Emissions*** *by providing new renewable energy supplies and carbon sequestration on contaminated lands that promote both land reuse and energy diversity. The framework set forth in this project can also help to increase long term regional, national, and global environmental stewardship by decreasing or offsetting greenhouse gases.*
2. ***Objective 2.2: Protect Water Quality, Sub-objective 2.2.1: Improve Water Quality on a Watershed Basis*** *by reclaiming and restoring mine lands and reducing acid mine runoff. Over 5,000 stream miles in EPA Region III are impacted by acid mine runoff.*
3. ***Objective 3.2: Restore Land, Sub-objective 3.2.2 Clean Up and Revitalize Contaminated Land*** *by reclaiming and reusing abandoned coal mine sites in EPA Region III in a sustainable manner that produces clean, renewable energy and stimulates the local economy.*
4. ***Objective 4.2: Communities, Sub-objective 4.2.3, Assess and Cleanup Brownfields*** *by reclaiming and reusing abandoned coal mine sites in EPA Region III in a sustainable manner that produces clean, renewable energy and stimulates the local economy.*

In addition to EPA's strategic plan, this project directly benefits EPA's priority for Clean Energy and Climate Change, specifically the Office of Solid Waste and Emergency Response Climate Change and Contaminated Lands workgroup strategy by siting renewable energy facilities as a beneficial reuse on contaminated lands.

Appalachian Regional Commission Strategic Objectives

This project meets the following strategic objectives for economic and energy development of the Appalachian Regional Commission:

1. ***Promote energy efficiency in Appalachia to enhance the Region's economic competitiveness.***
2. ***Increase the use of renewable energy resources, especially biomass, in Appalachia to produce alternative transportation fuels, electricity, and heat.***

Performance Measurements: Outcomes and Outputs

Outcomes

1. The reduction of sediment and mine drainage due to the substantial root system of biofuel crops. This would reduce the cost of water treatment in affected watersheds.

   Actual on-the-ground planting of biomass is not an objective of this study; however based on known characteristics of biomass root systems, such as size and absorption rates, plantings can be evaluated and calculations made to determine mine site sedimentation and AMD reduction in accordance with site conditions.

2. Measurable carbon sequestration:

   Actual on-the-ground planting of biomass is not an objective of this study; however carbon sequestration based on actual biomass plantings can be determined through intensive soil sampling and measurement of biomass crop growth rates.

3. Number of acres of mine-scarred lands feasible for productive reuse: 295,632 acre total for 612 Candidate SEP sites in West Virginia

4. Number of West Virginia County Extension Agents trained on the use of switchgrass as a biofuel on mine-scarred lands in WV: 5

   While West Virginia County Extension Agents are a good resource to share information about the SEP Project within their geographic area, the infrastructure of the extension service and the primary duties of the agents did not prove conducive as a training "target" for biomass production. Five agents showed an interest based on their individual backgrounds in advocating biomass production on mine scarred lands as a post mine land use option. Economic Development Authorities in West Virginia have proven to be a better cooperating agency.

5. Number of communities engaged in renewable energy production that have historically been coalfield producing communities: 2; McDowell and Grant Counties, West Virginia

6. Number of sites with Phase 1 assessments: 1 project was identified for the purposes of this project; Indian Ridge, McDowell County site

7. Number of sites listed in the inventory: 612 Candidate SEP sites

8. Number of community meetings held: 15

9. Number of briefings with Economic Development Authorities: 6

Outputs

1. Quarterly progress reports: 13

2. Quarterly financial reports: 13

3. Final Project Report: 1-Pending

4. Site selection criteria: 30+

5. Inventory of Candidate SEPs: 612

6. Prioritization Tool: 1

7. Request for Proposals: 1

8. Proposals Received: 2

9. Proposal Development Training Workshops: 2

10. Development Plan: 1
11. Business plan: 1
12. Investment plan: 1
13. Marketing plan: 1
14. Comprehensive Development Plan: 1
15. WVU County Extension Agents Training Workshop: 1
16. Dissemination Products: 6
    - Brochure recipients: ~700
    - Events at which project factsheet was distributed: 10
    - Project webpage: 1
17. Events held to showcase pilot SEP project: 3

Chapter 3 - Methods and Results

The researchers completed project tasks through literature review, Geographic Information System (GIS) analysis, stakeholder engagement, economic and environmental analyses, review of sustainable energy technologies and markets, and solicitation of community input.

Site Identification Process

The site selection for this project was completed through a careful step-by-step process. The research team started with over 15,000 sites identified from GIS analysis and West Virginia Department of Environmental Protection (WVDEP) permit data. The initial total number was reduced through multiple steps using different levels of GIS analysis and decision-making. The team eventually reduced this number to 612 Candidate Sustainable Energy Park (SEP) sites through site characteristic GIS analysis. Beyond the research team's site characteristic analysis, then evaluated were the 612 sites using established United States Environmental Agency (USEPA)/National Renewable Energy Laboratory (NREL) screening documents to determine the viability of each energy type per site.

Mining Dataset Creation and Initial Analysis

The first step in determining our potential SEP sites involved creating a geospatial database of approximately 15,000 active and inactive permitted mine sites and abandoned mine lands from GIS files obtained from the WVDEP. Once these sites were imported in the first iteration of the GIS spatial analysis platform using the Environmental Systems Research Institute's (ESRI) ArcGIS® software, the GIS files were manipulated to create a single dataset with all aforementioned sites. To arrive at the initial single dataset that could be used in further GIS analysis, these steps were completed:

- Underground mines from active and inactive permitted mine sites were extracted and removed
- Surface mine sites were identified and saved for future GIS analysis
- Permitted mine GIS file was merged with the abandoned mine land GIS files, while retaining borders of all sites
- Adjacent tracts of mine land (<100m distance) were combined regardless of operator ownership with ArcGIS® generalization tool
- All associated data in GIS tables was transferred and maintained with the site boundaries

Mine Lands Evaluated

For the initial evaluation of mine lands, aggregated sites comprised of 5,000 or more acres with less than 15% slope were identified. For this preliminary evaluation, 11 sites met these criteria and were ranked by size. A wind class dataset (50 meters above ground) from the NREL was added to the GIS. The wind industry divides wind resources into seven classes, ranging from poor (Class 1) to superb (Class 7). Wind farms are typically sited where the resource is Class 3 through 7 (U.S. Department of Energy, 2008). Figure 1 depicts the top 11 sites, showing wind class, aggregated parcels with at least 5000 acres ≤15% slope, abandoned and permitted mine boundaries, and bond forfeiture sites.

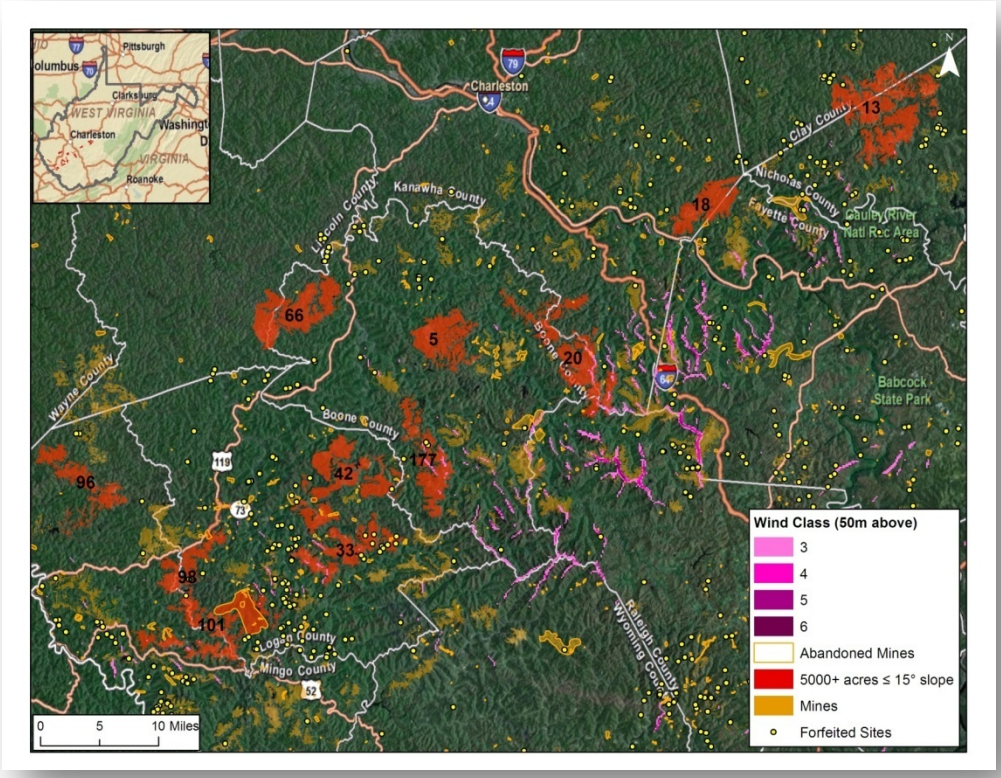

Figure 1. Map depicting preliminary top 11 aggregated surface mine sites.

As the project continued, updated shapefiles from the National Land Cover Database were included. As it was realized that slopes greater than 5% were simply not feasible for the planting and harvesting of biofuels, elevation shapefiles were reclassified to further define the locations of potential SEP sites. Slope elevations were re-categorized as: ≤1%, ≤2%, ≤3%, ≤4%, ≤5%, and >5% for the entire state of West Virginia. The majority of the state is greater than 5% slope, so only slopes less than and including 5% are shown in color on the map. This further analysis revealed eight large tract land sites which were identified and labeled according to the coal mining operation that held most of the permits in the general area (Figure 2).

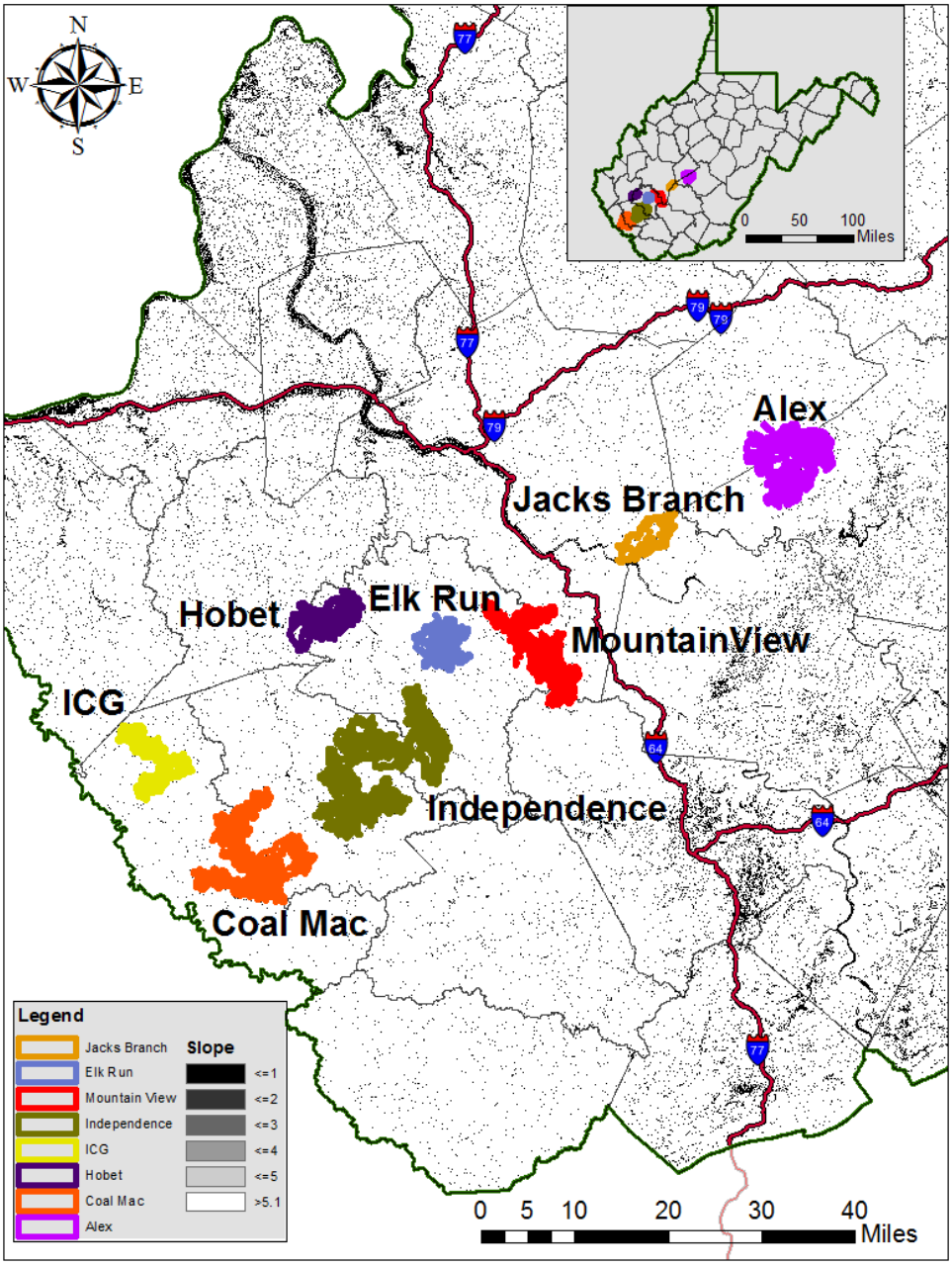

Figure 2. Selected large tract mine sites with 0-5% slope.

Each of the eight identified sites (Jacks Branch, Elk Run, Mountain View, Independence, ICG, Hobet, Coal-Mac, and Alex) contain smaller mined areas, all within varying stages of the mining and reclamation process. Collected information was reorganized as it related to these permit areas and from running a *Master Cost Spreadsheet,* developed as a component of this project, for a complete analysis. Factoring in distance to utilities and current infrastructures, along with the specific permit status information, is valuable to the market analysis portion of the project. A land cover layer has been added to show mined areas in relation to their current land uses (Figures 3 through 10).

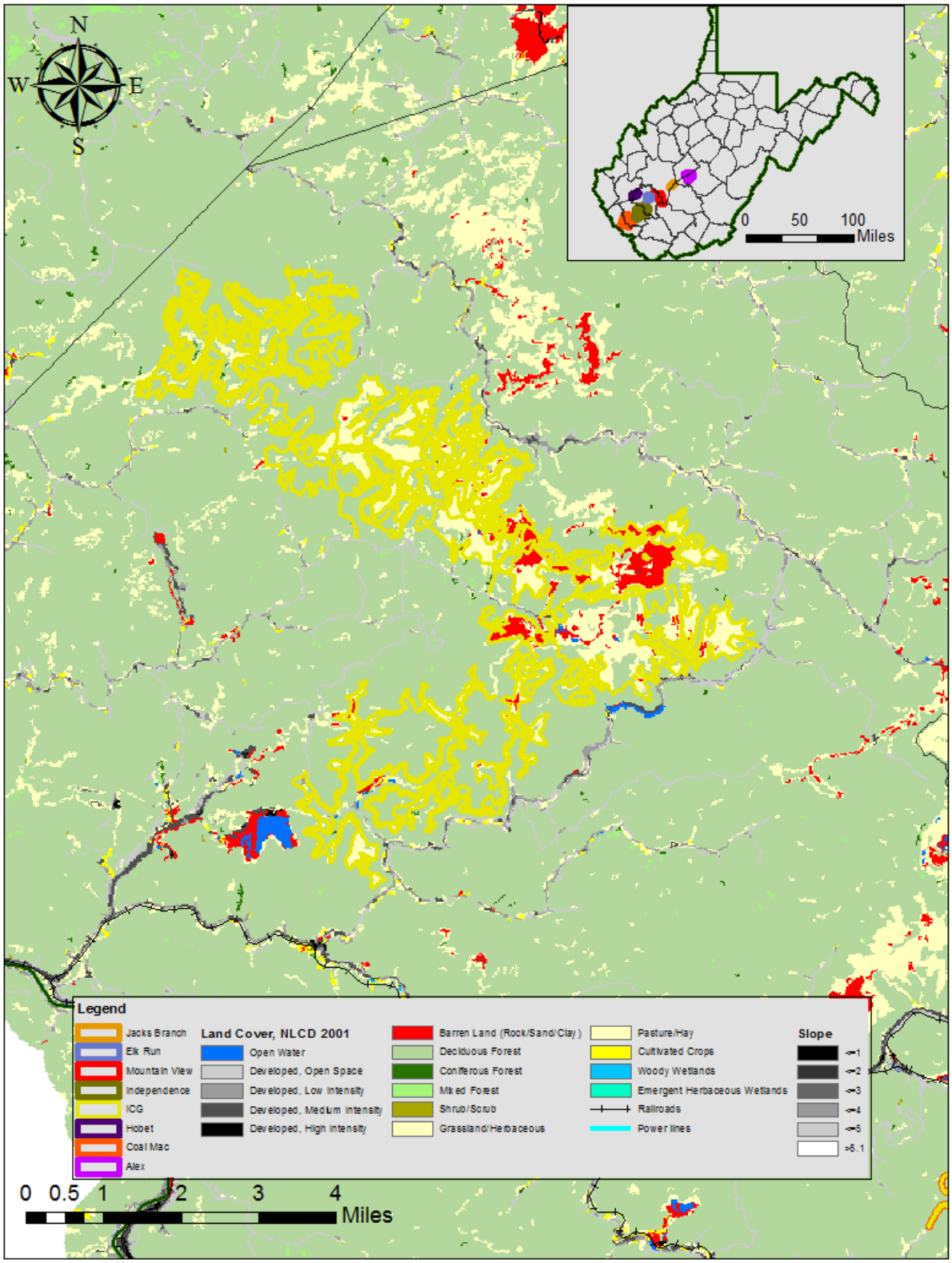

Figure 3. Land use cover for the International Coal Group (ICG) site, Mingo County, West Virginia.

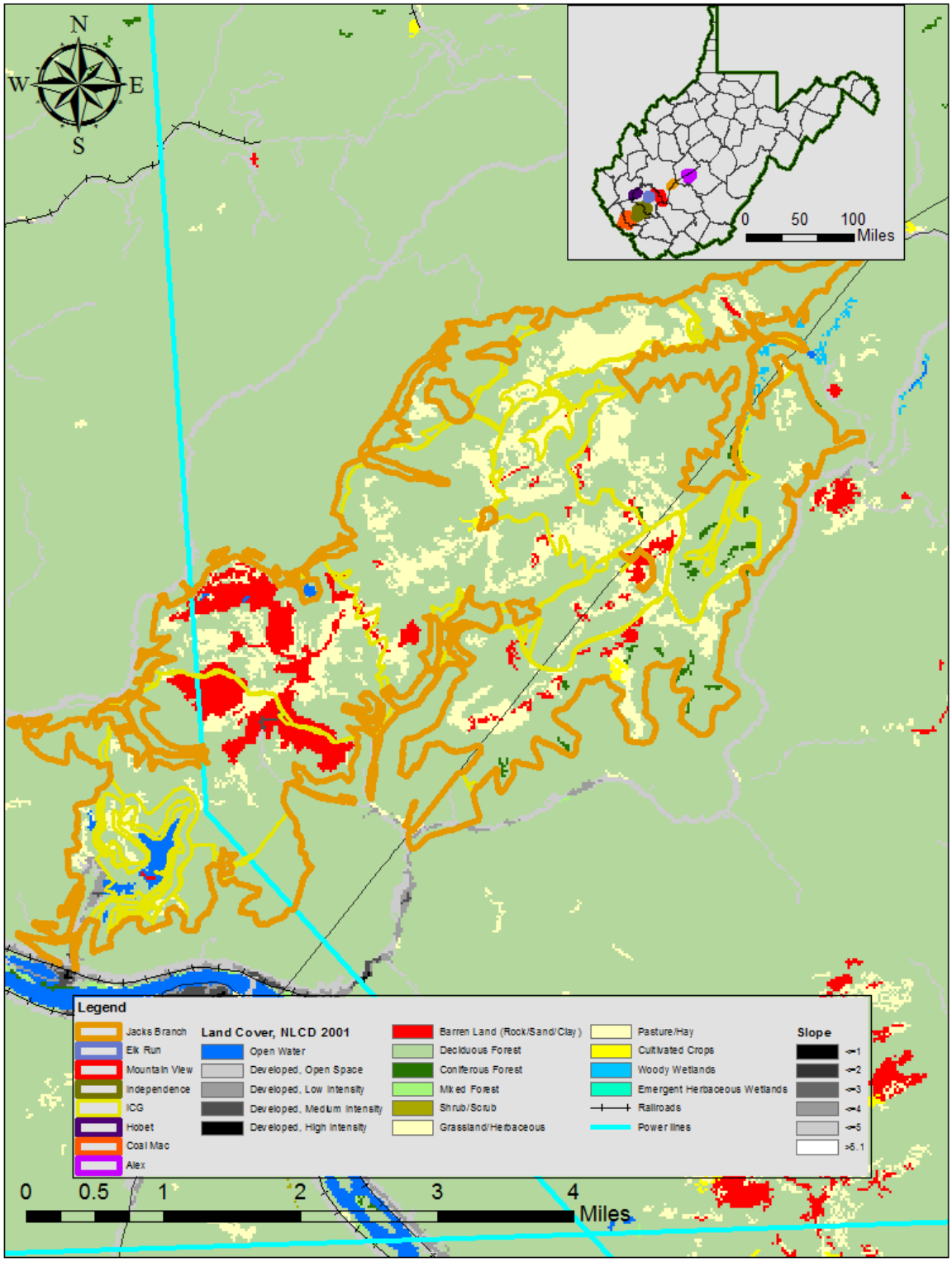

Figure 4. Land use cover for the Jacks Branch site, Kanawha County, West Virginia.

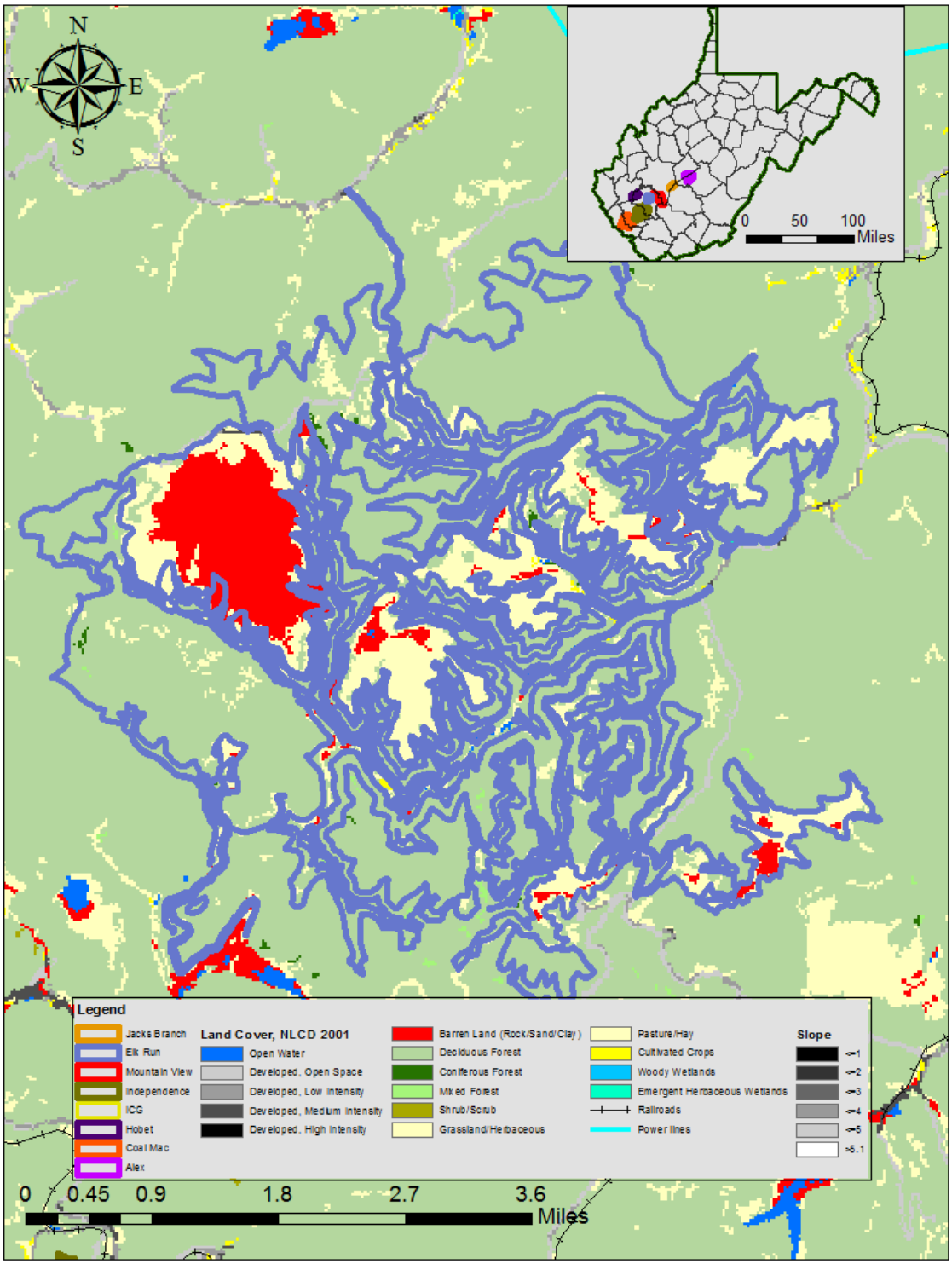

Figure 5. Land use cover for the Elk Run site, Boone County, West Virginia.

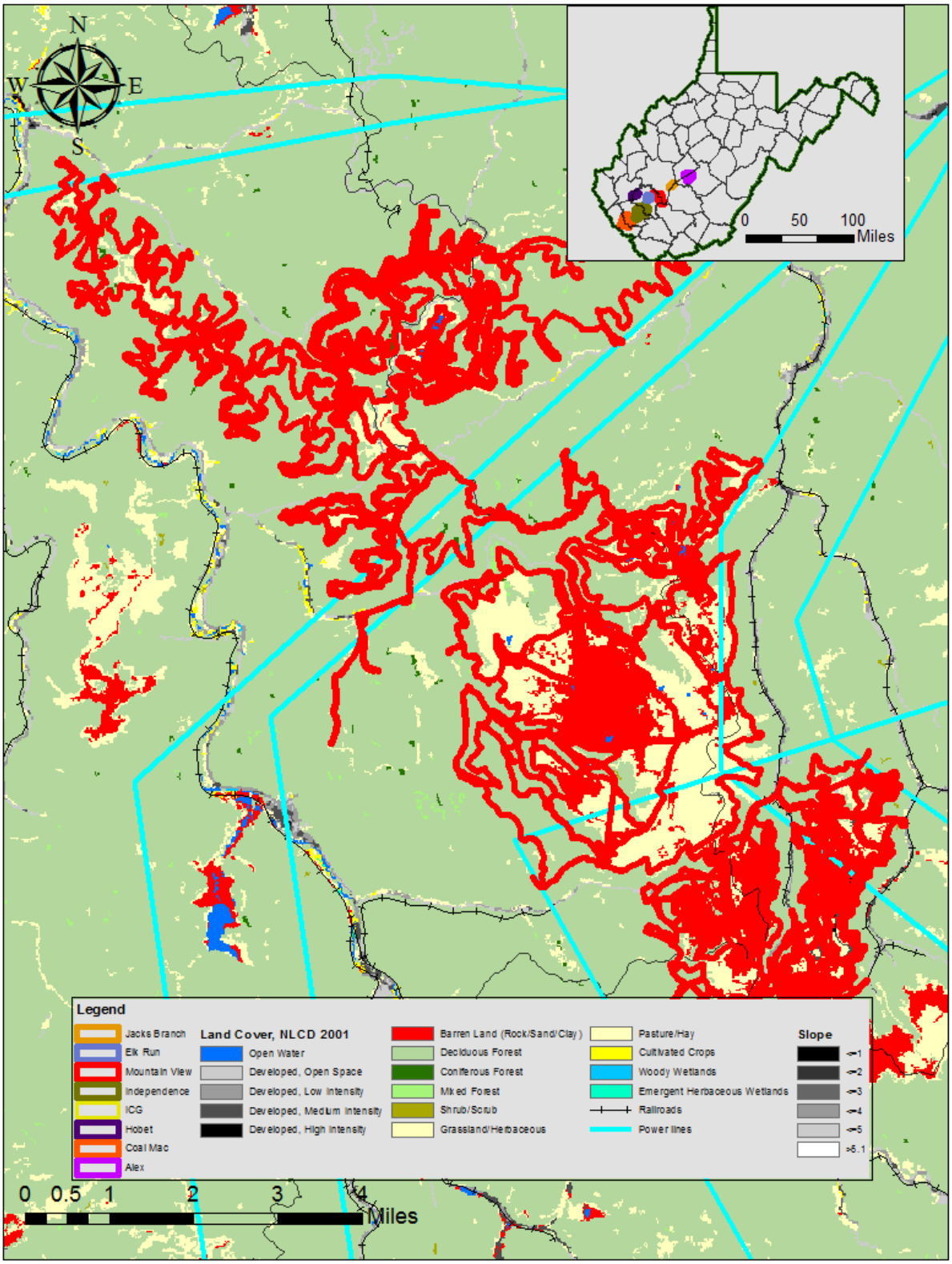

Figure 6. Land use cover for the Mountain View site, Boone County, West Virginia.

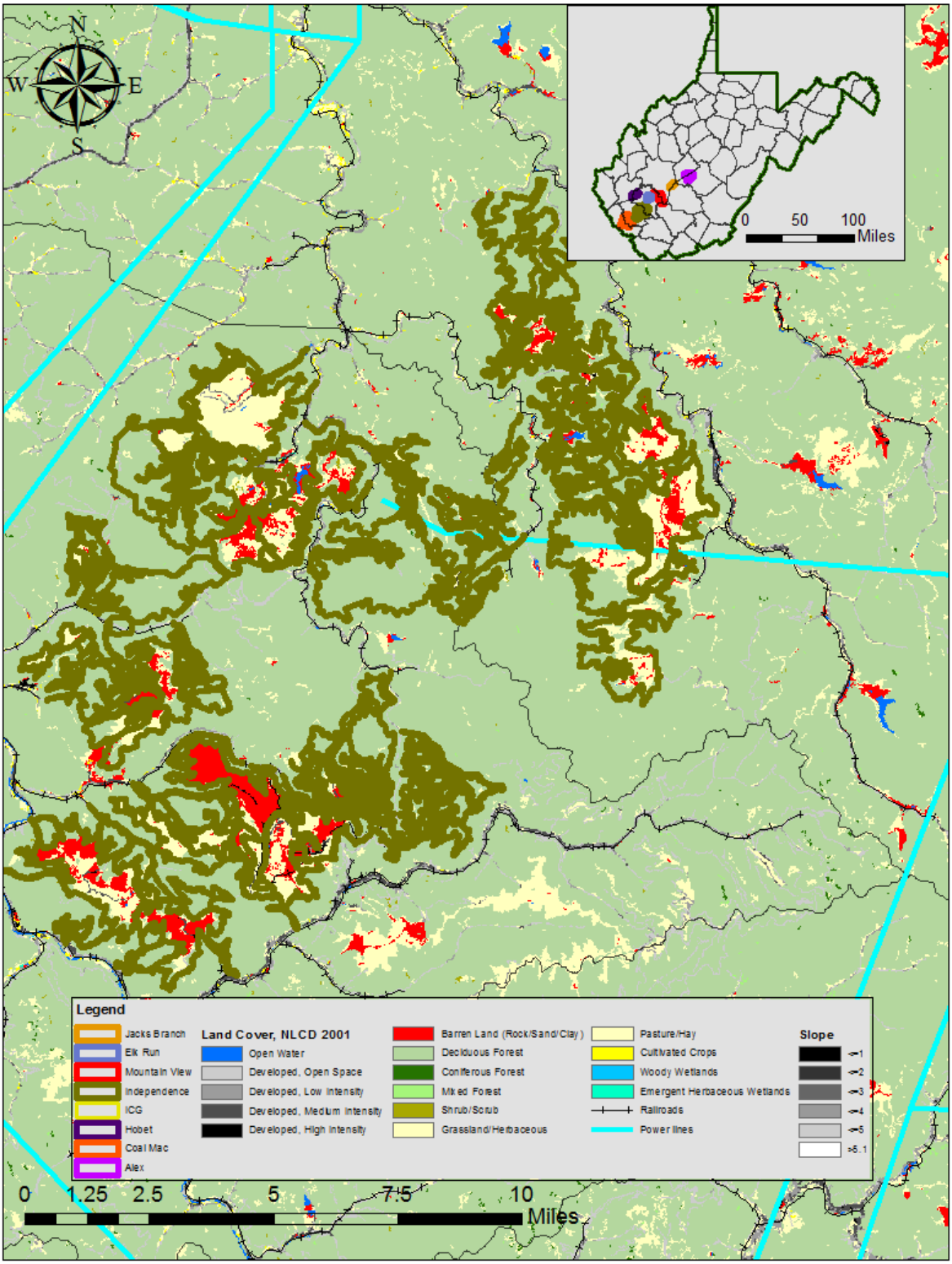

Figure 7. Land use cover for the Independence site, Logan and Boone Counties, West Virginia.

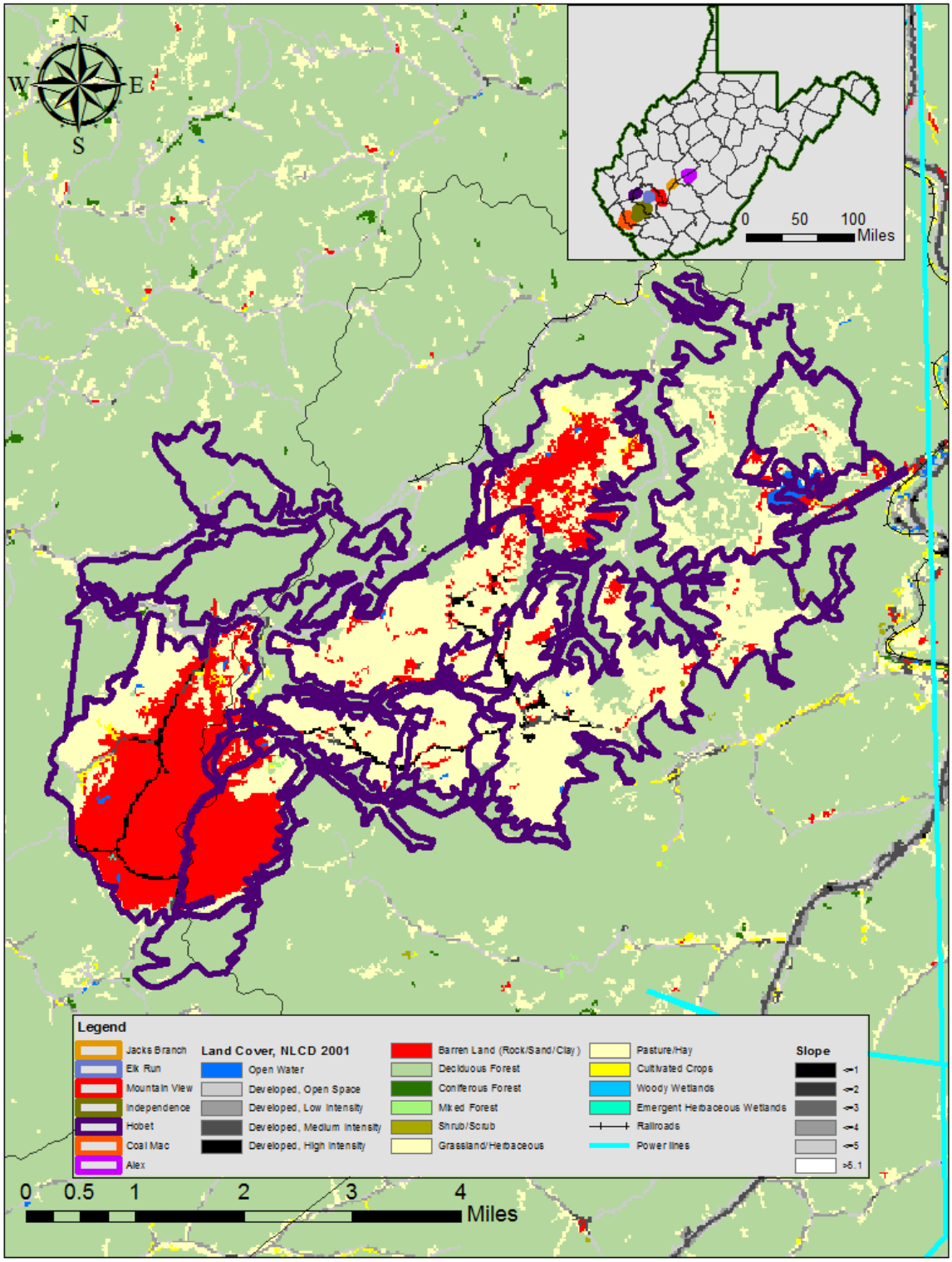

Figure 8. Land use cover for the Hobet site, Boone County, West Virginia.

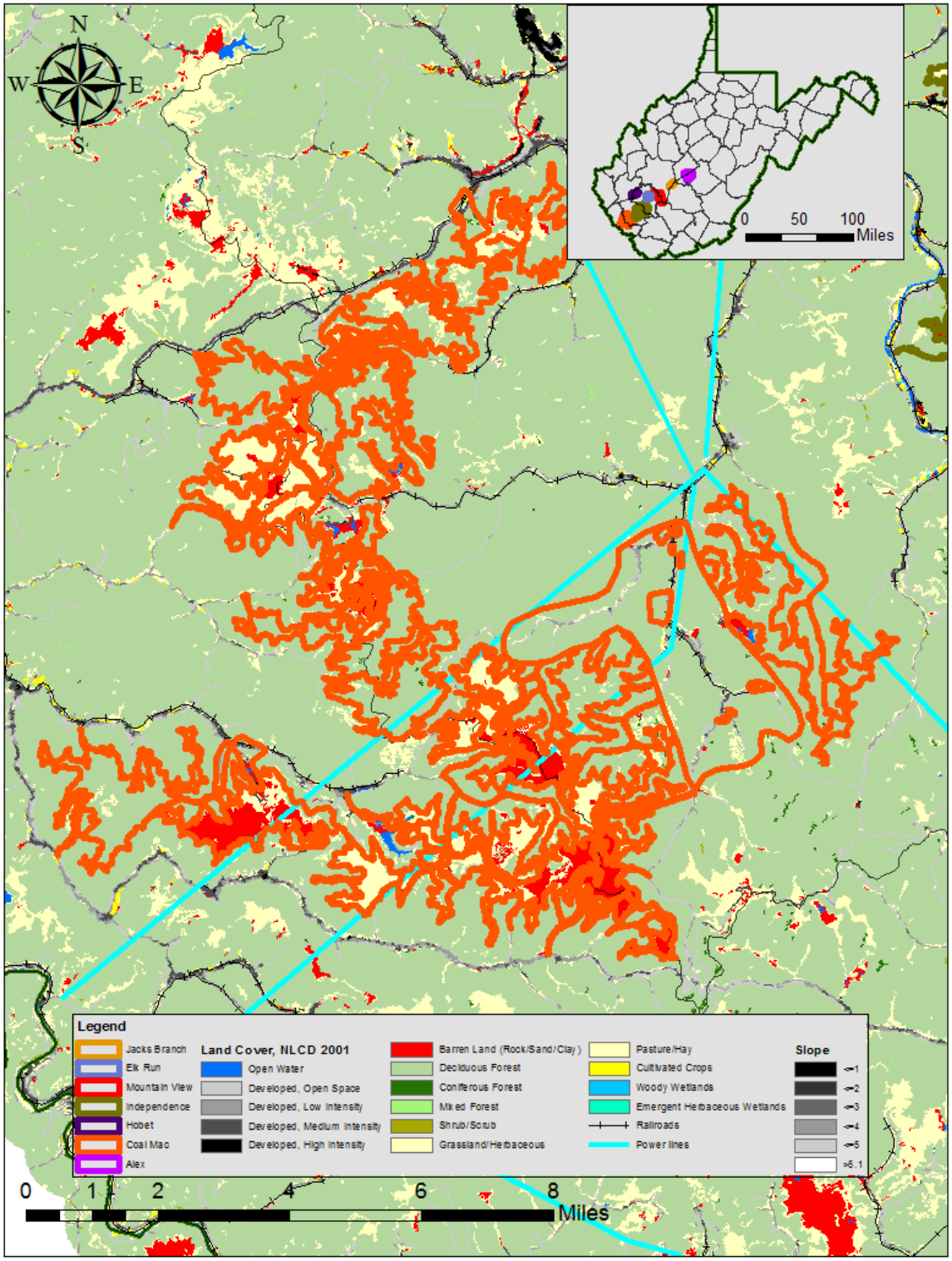

Figure 9. Land use cover for the Coal-Mac site, Mingo and Logan Counties, West Virginia.

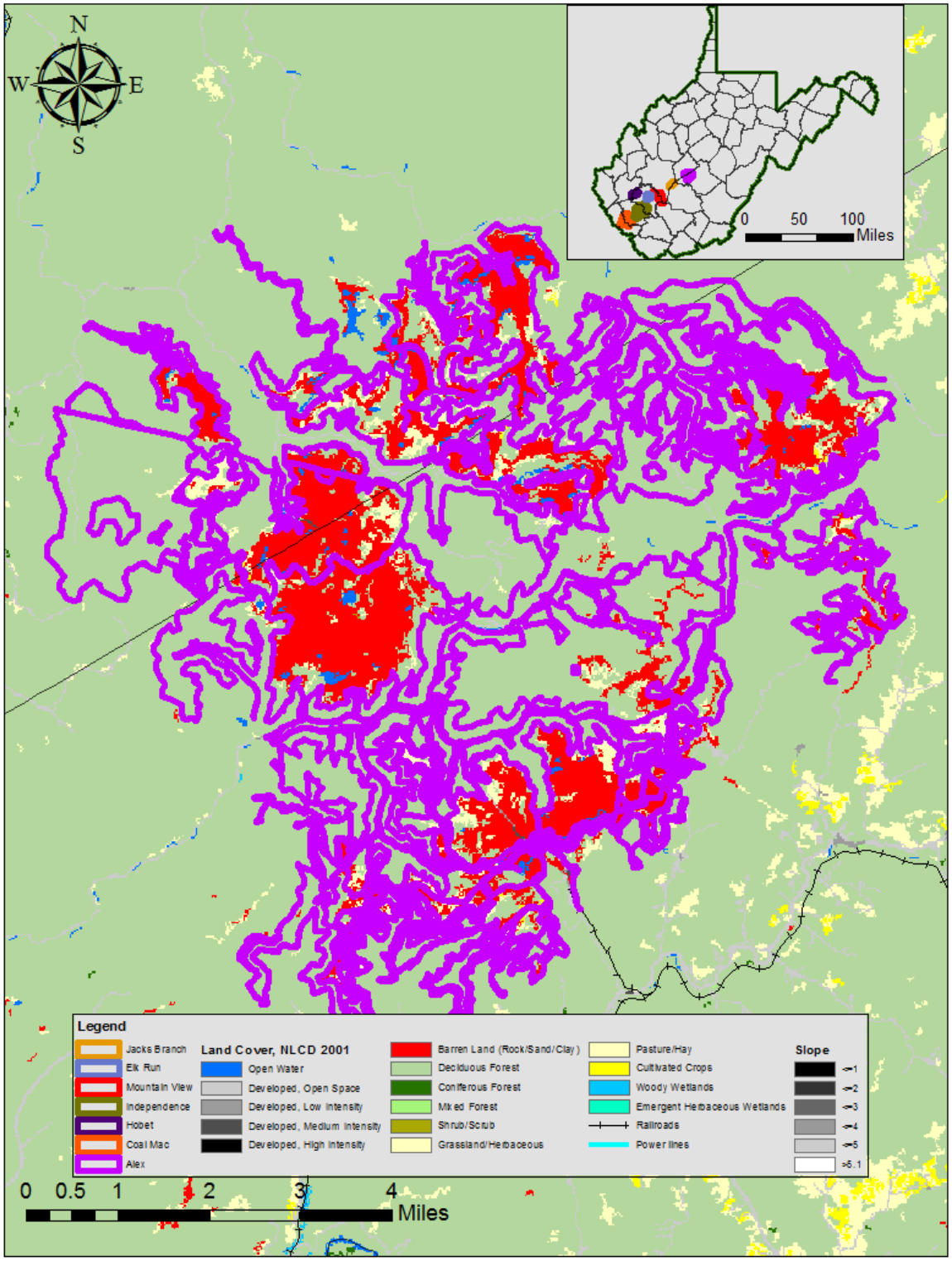

Figure 10. Land use cover for the Alex site, Clay and Nicholas Counties, West Virginia.

As evident in the above figures, several large tracts were identified which contain a large area of "barren land." Additionally, these sites often contain multiple mine permitted tracts.

The initial ranking was useful in realizing that there were often contiguous mined areas consisting of multiple permits in various stages of the permitting process (i.e. reclaimed, current mining, etc.). However, as the project further developed, the data source methodology was further refined to determine and ultimately rank the 612 possible SEP sites in West Virginia.

Additional features to the GIS platform included property boundaries and the Trans Allegheny Interstate Line (TrAIL) transmission path for use with the site ultimately selected for the pilot study. The site selection methodology was also reconfigured to more accurately account for mining disturbed areas greater than 100 acres.

Data layers from the National Agriculture Imagery Program (NAIP) Aerial Photography were utilized to derive high resolution land cover (Figure 11). This updated land cover data set provides a more recent account of existing land cover than layers that had been used previously.

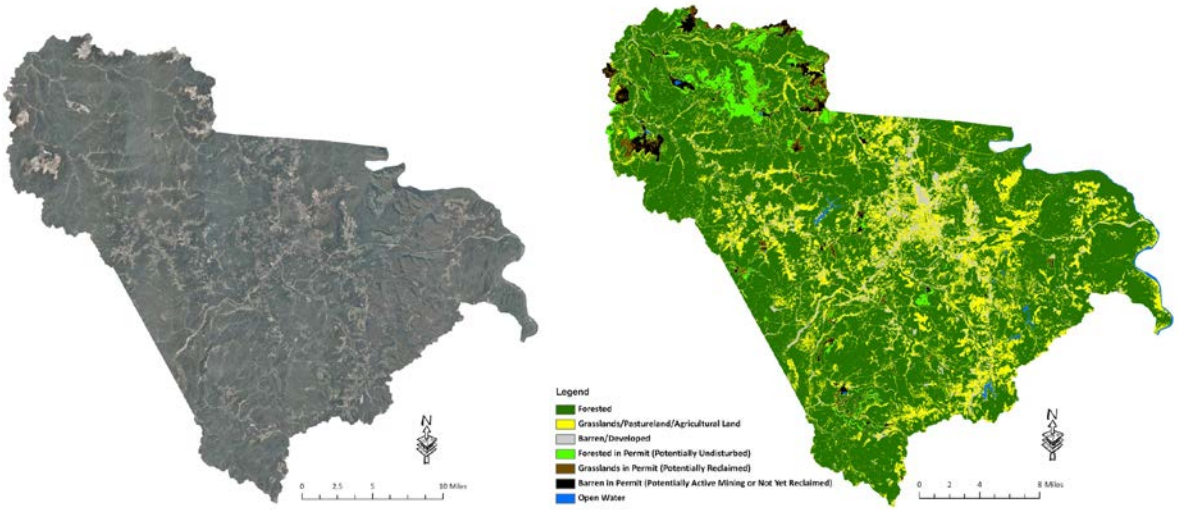

Figure 11. Aerial imagery (left) and high resolution land cover (right) of Raleigh County, West Virginia.

The resultant high resolution land cover layers were further enhanced by adding in digitized layers of the West Virginia Southern Coalfields (Figure 12).

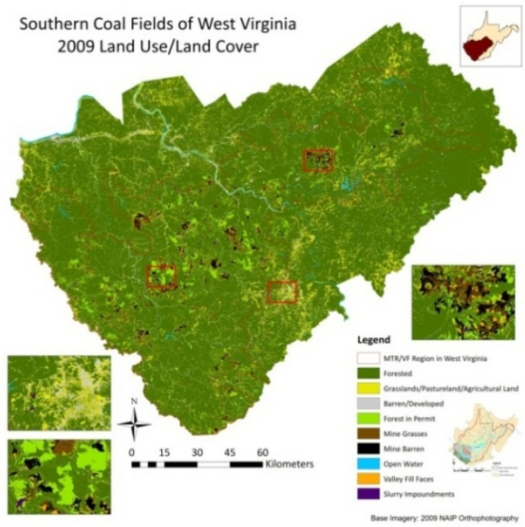

Figure 12. Digitized southern West Virginia coalfields.

These digitized layers provide valuable, detailed information regarding the land cover available for possible biofuels production and other sustainable energy possibilities on formerly mined lands. Additionally, Light Detection and Ranging (LiDAR) technology that was not available in 2008 has recently become available for many parts of West Virginia. This data can be utilized for site specific terrain modeling. Site specific LiDAR is shown in Figure 13.

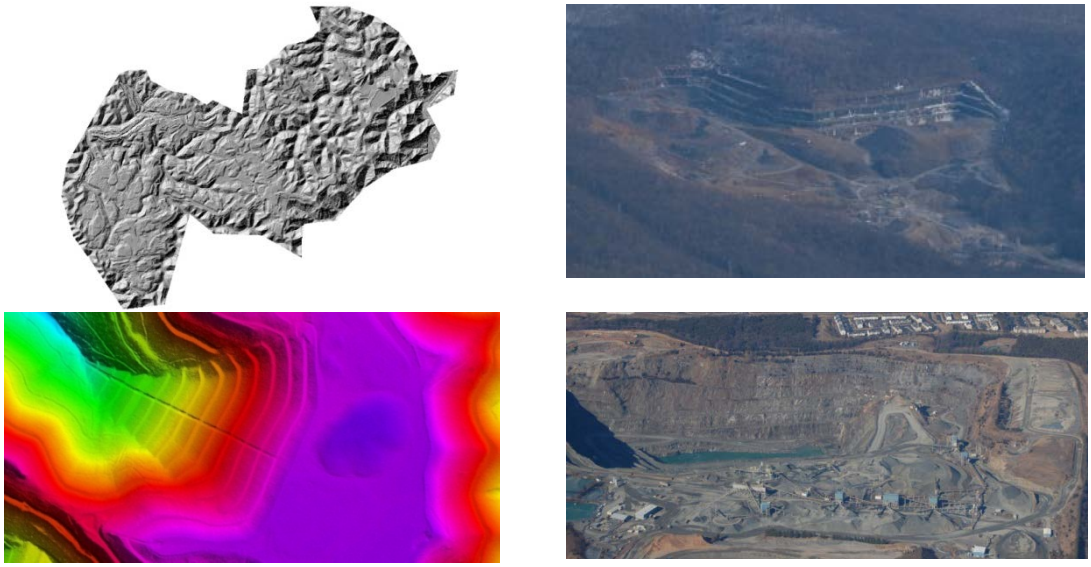

Figure 13. LiDAR images used to create terrain models.

Preliminary Site Surveys

In order to accurately verify the data that was gathered from the GIS portion of this project, it was necessary to travel to some of the potential SEP sites to ground-truth for purposes of accuracy. Based on the preliminary ranking of mine lands, a site visit was made to Logan County, West Virginia, to the Coal-Mac site owned by the Arch Coal Company. Project team members traveled to the site and verified the various features, landforms, and infrastructures revealed from the GIS mapping. On this trip, team members met with mine personnel, collected soil samples, took photographs of the various features, and collected coordinates for potential wind turbine locations. The results of the trip were that most of the information gathered during the initial GIS portion of the project proved to be accurate. The areas where mining was currently being performed were not as accurate, which can be attributed to the constant mining process. Photographs were taken while on site and are accompanied by a brief description (Figures 14 through 16). Although these preliminary eleven sites were later revised into the more detailed ranking through the data source methodology, the site visit proved beneficial to researchers for ground-truthing information provided by the GIS outputs.

Figure 14. Reclaimed mine area suitable for biofuel production at the Coal-Mac site in Logan County, West Virginia.

Figure 15. Portion of the Coal-Mac site in Logan County, West Virginia that is currently undergoing mining.

Figure 16. Plateau area in reclaimed portion of the Coal-Mac site in Logan County, West Virginia.

Researchers contacted land managers to gain access to selected sites in southern West Virginia. Project researchers conducted site visits to the top selected sites (Figure 17), listed below:

1. Samples Mine – Catenary Coal (Raleigh Co.)
2. Phoenix 1 – Coal-Mac (Mingo Co.)
3. Phoenix 2 – Coal-Mac (Mingo Co.)
4. Phoenix 3 – Coal-Mac (Mingo Co.)
5. Phoenix 4 – Coal-Mac (Mingo Co.)
6. Hobet (Lincoln Co.)
7. White Flame (Mingo Co.)

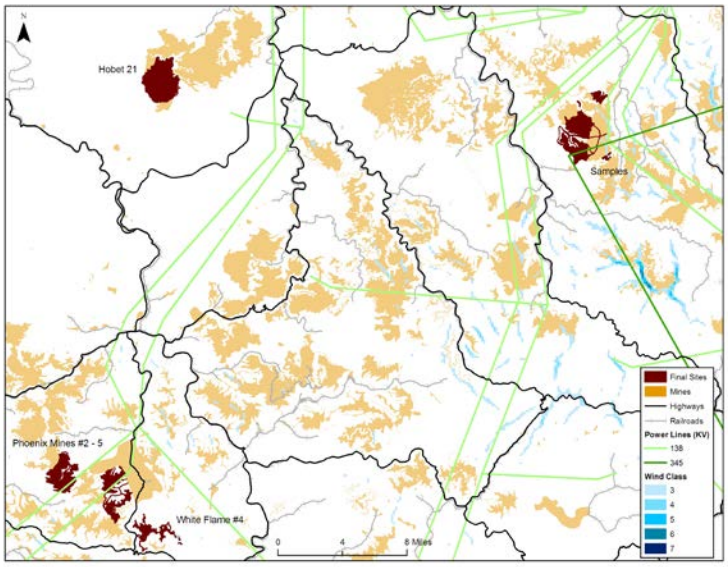

Figure 17. Locations of selected surface mine sites in West Virginia.

In addition to verifying spatial analysis, the visit proved useful in determining the feasibility of cultivating (planting and harvesting) switchgrass with conventional agricultural methods and equipment. Site characteristics particular to switchgrass cultivation include: Land slope, contour, as well as soil nutrient content and structure. Researchers assessed current site vegetation and access issues, as well as whether topography was conducive to planting. Soil samples were collected and characterized with respect to their physical and chemical properties with the intent to determine costs of lime and/or fertilizer needed to produce maximum biomass on reclaimed surface mine areas.

Specifically, researchers:

1. Observed and recorded site conditions;
2. Compared on-the-ground GPS coordinates with GPS coordinates in the data set to determine how well they matched up, making any necessary corrections;
3. Took field measurements for slope;
4. Took photographs;
5. Identified areas that may be applicable for biofuels (i.e., switchgrass versus woody mass) depending on site conditions such as slope, scrub brush, rock and soil conditions, wind, solar, etc.; and
6. Collected soil samples.

The preliminary site visits proved useful in developing protocols for additional targeted site visits.

Soil Sample Results

Preliminary soil samples were collected and analyzed to provide baseline data for mine soils in the region. Mine soil samples were collected from three surface mine sites visited - Samples, Wildcat, and Hobet (Table 1). The samples were analyzed by West Virginia University's Soil Test Lab. Analytical results are shown in Appendix A. The pH of the soil samples ranged from 5.9 – 8.1 s.u. which is typical of southern West Virginia soils and an acceptable range for switchgrass establishment. In addition, phosphorus, potassium, calcium, and magnesium levels were rated from high to very high and considered sufficient for grass production without fertilizer addition. Direct soil nitrogen analysis is not possible but nitrogen addition in the first year of switchgrass establishment is discouraged because it encourages weed growth that competes with the switchgrass. The amount of subsequent annual nitrogen addition is dependent upon the first year's production and the desired yield goal.

Table 1. Mine site soil sample location descriptions.

Mine Site Soil Sample Location Descriptions	
Sample Site:	**W-1**
Mine:	Wildcat
Site Description:	A re-mining area with contour cuts and highwall mining. Sample area was reclaimed 2 to 3 years ago with good to very good grass coverage. Penetration depth of 10 to 12 inches with mattock and shovel.
Slope:	Approximately 2:1
Aspect:	Westerly
Sample Site:	**W-2**
Mine:	Wildcat
Site Description:	A re-mining area with contour cuts and highwall mining. Sample area was reclaimed 2 to 3 years ago with good to very good grass coverage. Penetration depth of 10 to 12 inches with mattock and shovel.
Slope:	Approximately 2:1
Aspect:	Southerly
Sample Site:	**S-1**
Mine:	Samples
Site Description:	A dragline spoil area which was reclaimed approximately 10 to 12 years ago with good grass coverage and woody vegetation. Penetration depth of 6 to 8 inches in depth with mattock and shovel.
Slope:	Approximately 4:1
Aspect:	Northerly
Sample Site:	**S-2**

Mine:	Samples
Site Description:	A dragline spoil area which was reclaimed approximately 10 to 12 years ago with good grass coverage and woody vegetation. Penetration depth of 6 to 8 inches in depth with mattock and shovel.
Slope:	Approximately 6:1
Aspect:	Southwesterly
Sample Site:	**H-1**
Mine:	Hobet 21
Site Description:	A reclaimed contour mining area which was reclaimed over 20 years ago with good grass coverage and trees 2 to 12 inches in diameter. Penetration depth of 10 to 12 inches with mattock and shovel.
Slope:	Approximately 2:1
Aspect:	Southerly
Sample Site:	**H-2**
Mine:	Hobet 21
Site Description:	A reclaimed contour mining area which was reclaimed over 20 years ago with good grass coverage and trees 2 to 12 inches in diameter. Penetration depth of 10 to 12 inches with mattock and shovel.
Slope:	Approximately 3:1
Aspect:	Northerly

Enhanced Site Selection Criteria and Analysis

The team identified a list of more than 30 site characteristics criteria that could be used to reduce the number of candidate sites from the more than 15,000 sites identified. A subset of the 30+ characteristic criteria was used to reduce the total number to 612 Candidate SEP sites. Distances to transmission lines, railroads, and highways were calculated using a standard GIS proximity tool, and slope was calculated using standard GIS spatial analysis tools. Slope and land cover (Homer, 2007) were each reclassified into major groupings (wetland, agricultural, grassland, shrub land, forest, water, development, or barren land uses, and 0 – 14.99 degree and greater than 15 degree slope classes). Zonal statistics were run on each land cover type and slope grouping, and percent of these classes as well as maximum and mean slope within each mine aggregate were calculated. Acres of each land use class and slope class were calculated using percentage of total acres of each aggregated tract of land. A spreadsheet containing both aggregated parcels and individual permit boundaries was developed.

The aggregated parcel dataset includes the following information for each aggregated tract of land:

- Aggregate ID
- Area (acres)
- Distance to electric transmission lines, railroads, and major highways (miles)
- Area of agricultural, barren, developed, forest, grassland, shrub land, water, or wetland (acres)
- Maximum and mean slope
- Area greater or less than/equal to 15 degrees slope (acres)

The individual permit dataset includes:

- Aggregate ID (links data between the two data sets)
- Shape ID
- Type (permitted or abandoned)
- Permit (for permitted sites) or Pad ID (for abandoned sites)
- Facility name
- Permittee
- Operator

Criteria Descriptions

The following criteria descriptions are followed by the criteria used to determine site preferences.

Area of site (acres) – total area in acres of each surface mine; data from West Virginia Department of Environmental Protection (WVDEP) Surface Mine Permit (perbd.shp) GIS file; larger sites preferred

Slope (%) – percentage of each surface mine that falls within each of these categories: 0%-5%, 5%-10%, 10%-15%, 15%-20%, and >20%; derived from West Virginia Statewide Addressing and Mapping Board (SAMB) 3-meter; larger %age of no or shallow slope preferred

Slope (m^2) - area in square meters of each surface mine that falls within each of these categories: 0%-5%, 5%-10%, 10%-15%, 15%-20%, and >20%; derived from West Virginia SAMB 3-meter; larger area of no or shallow slope preferred

Wetlands (acres) – acreage of wetland features within each surface mine; data derived from United States Fish and Wildlife Service (USFandWS) National Wetlands Inventory; smaller acreage of wetlands preferred due to mitigation

Current Vegetation (competition) – area of forested, non-forested land cover within each surface mine site; larger acreages of non-forested land preferred

Streams, distance to closest (meters) – Euclidean (straight line) distance from each surface mine site to closest hydrology features, which include lakes, ponds, reservoirs, and double line streams; derived from 2003 West Virginia SAMB surface water features; smallest distances preferred

Abandoned mine land distance (meters) – Euclidean (straight line) distance in meters between surface mine and closest abandoned mine land. Sites with a value of 0 are abandoned mine lands within boundary of surface mine; derived from dataset compiled by the West Virginia Office of Abandoned Mine Lands and Reclamation (AMLR) and WVDEP Surface Mine Permit (perbd.shp) GIS file

Mine permit status – presence or absence of any type of current mine permit; data from WVDEP Surface Mine Permit (perbd.shp) GIS file

Aspect, south facing (%) – percent of each surface mine that faces south (135-225 degrees); derived from 2003 9-meter SAMB digital elevation model (DEM); surface mine sites with highest %age of south facing aspect preferred

Highway, distance to (miles) – distance in miles from each surface mine site to nearest interstate on-ramp; derived from West Virginia Department of Transportation (WVDOT) Major Roads GIS file and WVDEP Surface Mine Permit (perbd.shp) GIS file; surface mine sites with least distance to nearest highway on-ramp preferred.

Railways, distance to (miles) – Euclidean (straight line) distance from each surface mine site to nearest intermodal (railroad) terminal; derived from using 9m Raster measurements

Town/city, distance to nearest (miles) – distance of each surface mine site to nearest towns, cities, and incorporated places; derived from United States Census Roads file, United States Census Populated Places file, and WVDEP Surface Mine Permit (perbd.shp) GIS file

Wind speed (class) – wind speed categories from 1 (poor) to 7 (superb); 2003 National Renewable Energy Laboratory (NREL) data from TrueWind LLC; surface mine sites with highest wind speed class preferred

Power plants, distance to closest (Meters) – Euclidean distance in meters from each surface mine site to closest power plant; derived from 2003 West Virginia Department of Energy powerplant dataset; surface mine sites with shortest distance to power plants preferred
Powerlines, distance to closest (Meters) – Euclidean minimum distance in meters from each surface mine site to closest transmission powerlines; derived from 2008 WVDNR Electricity Distribution Infrastructure dataset; surface mine sites with shortest distance to powerlines preferred
Substations, distance to closest (Meters) – Euclidean distance in meters from each surface mine site to closest power substation; derived from 2008 WVDNR Electricity Distribution Infrastructure dataset; surface mine sites with shortest distance to substation preferred
Water supply, distance to closest (Meters) – Euclidean distance in meters from each surface mine site to closest municipal water supply; derived from various Natural Resource Analysis Center (NRAC) files; surface mine sites with shortest distance to municipal water supplies preferred

Data Source Methodology
To ensure that all potentially applicable layers had been acquired, a "data source methodology" spreadsheet was developed. This spreadsheet contains: Factors, Importance, Source, Methodology, Completion, Biomass, Wind, Solar, Geothermal, Data Available, Data Source, Dataset, Source Date, Available Date, Resolution, and Notes. These column headers provide the organizational structure necessary to identify all layers acquired and needed as well as the ability to rank the importance of the layers. Researchers collectively and objectively determined which layers were of the most importance, e.g., a paved road within a mile weighs more heavily on site selection than having a pelletizing facility within 50 miles. This is not saying that the proximity of the pelletizing station is not important but that if a paved road is not close to the site, the ability to access the site for construction of wind turbines, hauling of harvested switch grass, etc. could render the site unsuitable, regardless of whether or not a pelletizing facility is nearby. Limiting factors were identified and ranked. This data source methodology is available in Appendix B.

General Data Layers
General data layers were further evaluated on a site-specific basis for alternative energy production potential focusing on the statewide coalfields region. Statewide data layers include basic infrastructure needs such as ground transportation (roads, railroads), power transmission lines, water resources, etc. Statewide layers include:

- Elevation and elevation-related derivatives (detailed 9m cell size)
    - Aspect
    - Moisture index
    - Slope
    - Concavity/convexity
    - Other landforms (coves, ridges)
- Rainfall (annual, monthly, extremes)
- Wind potential
- Roads
- Railroads
- Transmission lines (existing)
- Water resources
- Political/administrative boundaries
- Recent land cover, coalfields regions only (derived from 2009 United States Department of Agriculture (USDA) Inventory Program (Imagery - Aerial 1-m color Orthophotos NAIP, 2009).

Community-level and Site-specific Data Layers

Utilizing a more detailed map layer, more specific evaluation and characterization of a limited number of target sites were performed at the community-level. Site-level data layers include:

- Mine permit boundaries
- Mine permit features, where available (haul roads, etc)
- Parcel ownership, where available
- Existing structures
- Site-level infrastructure
- Site-level terrain analysis (utilizing NRAC/WVDEP detailed Light Detection and Ranging (LiDAR) mapping results for coalfields regions)

Site Selection to GIS Visualization

Modeling schematics were used to assist in the determination of data flow from the site selection criteria spreadsheet into an ArcGIS® format. Once the permit data has been run through the Excel® Site Criteria Spreadsheet, the output SEPs identified can be put back into the ArcGIS® for visualization purposes (Figure 18).

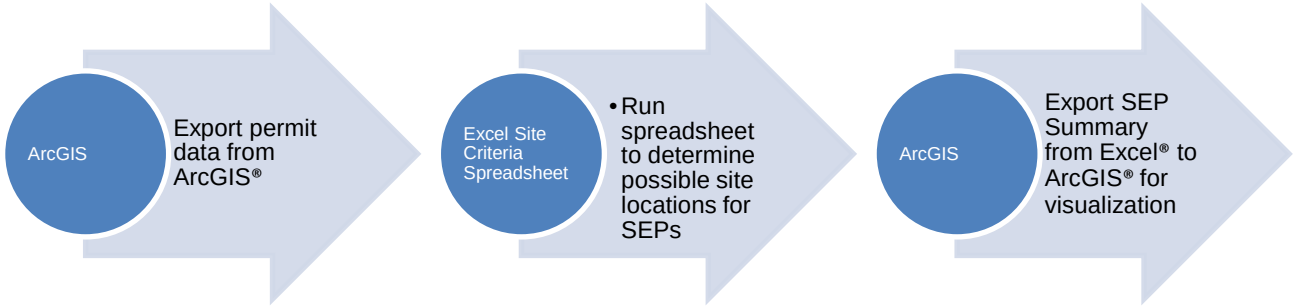

Figure 18. SEP data flow schematic.

Existing Infrastructure

Existing infrastructure for the 612 sites has been evaluated using the GIS data for this project. GIS shapefiles were used to visualize existing infrastructure (Figure 19).

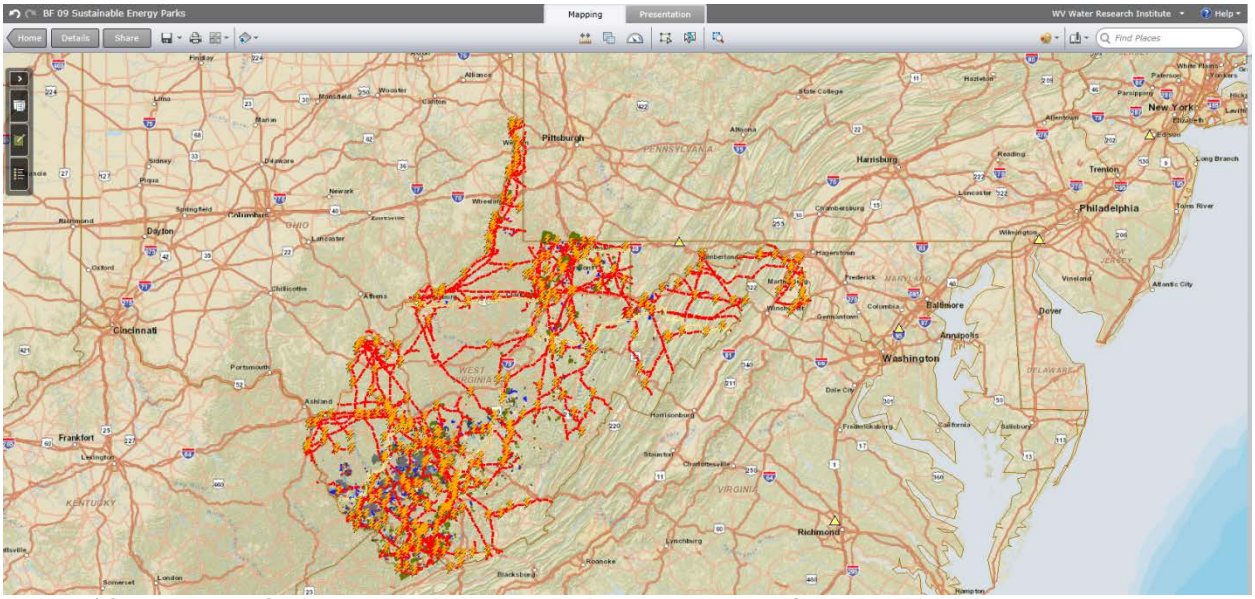

Figure 19. Potential SEPs locations in relationship to existing infrastructure in West Virginia.

Layers from West Virginia Water Research Institute were uploaded to the GIS server and include:

1. airports;
2. electric substations;
3. power plants;
4. Appalachian Development Highway (Corridor H);
5. powerlines;
6. railroad networks; and
7. potential SEP sites.

Additionally, GIS layers were pulled into the map from other agency GIS servers (this allows for the project map to be updated whenever other agencies update information on their GIS server). These additional layers include:

1. West Virginia mine permit boundaries;
2. United States Solar Energy development facilities;
3. solar energy potential;
4. National Oceanic and Atmospheric Administration (NOAA) current wind speed and direction;
5. Solar Programmatic Environmental Impact Statement (PEIS);
6. United States Median net worth;
7. United States Median household income; and
8. United States population density.

Interactive capabilities are demonstrated in Figure 20, as users are able to select map features for additional information.

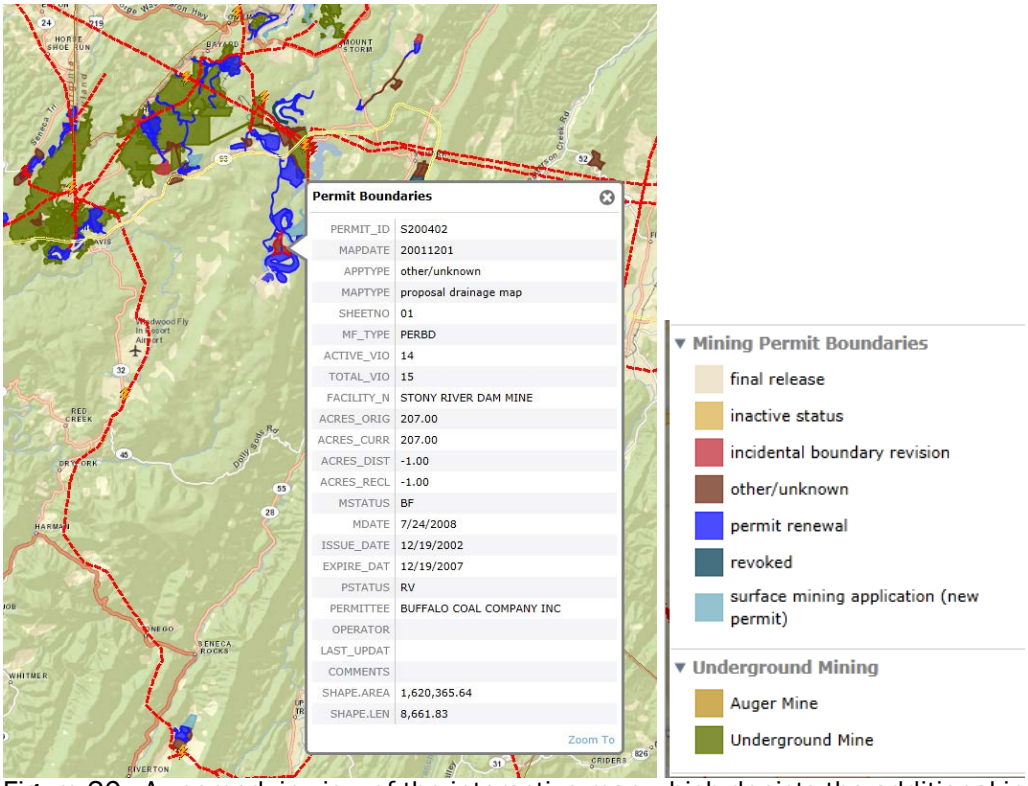

Figure 20. A zoomed- in view of the interactive map which depicts the additional information.

The approximate route of the proposed TrAil transmission line was also digitized (Figure 21).

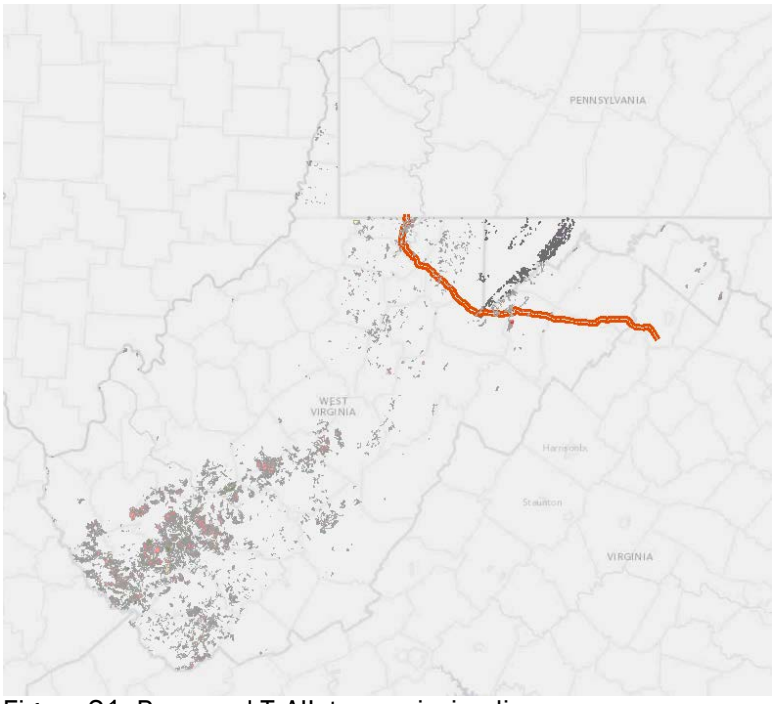

Figure 21. Proposed TrAIL transmission line.

The following variables were used for each of the categories:

Structures (STRUCT)
This is the number of structures identified in the 2003 SAMB dataset and are listed as points within the property boundary (West Virginia Statewide Addressing and Mapping Board, 2003).

According to the database, approximately 46.5% of the sites have some type of structure on site. The number of structures range from 1-126. Further field verification of the structures would need to be performed to determine if the buildings meet the size and amenities required for a SEP or if partial and/or complete retrofits would need to be made.

Power Supply (TRAN_LINES)
This is the Euclidean distance in meters from electrical transmission Lines to the property. This data was gathered from the West Virginia Division of Natural Resources (WVDNR, 2008).

According to the database, approximately 69% of the sites have transmission lines close to the properties. The average distance from those properties that have transmission lines nearby is 2,179 meters or 7,150 feet.

Existing Roads (Maj_int)
While there is no dataset for roads contained within the borders of these properties, there is a dataset that gives the distances to the nearest major intersection or on-ramp.

Of the 612 sites, over 99% of them are within close proximity to a major road and/or intersection. The average distance for these 612 sites is 14,995 meters or 9.3 miles.

Available Water (POPWATER)

This is the Euclidean distance in meters from public water supplies to the site (WV Infrastructure and Jobs Development Council, n.d.). According to the database approximately 79% of the sites are within close proximity to public water supplies. The average distance for these 79% of sites is 1,836 meters or 1.1 miles.

Indicators were evaluated using best available GIS data sources and various GIS-based analysis techniques. Some indicators could not be evaluated due to lack of statewide GIS data resources, particularly site properties related to parcels and ownership. Other indicators were evaluated on a statewide basis but were then reserved for more site-specific analyses. A complete listing of indicators considered and data sources used (if applicable) is available in Appendix C.

GIS Model Development

A three-dimensional (3D Studio Max®) schematic with alternative energy elements, wind turbines (three sizes/prototypes), solar Photo Voltaic (PV) panels, and vegetation forms for biomass, was developed (Figure 22). Case studies of alternative energy installations - wind, solar, geothermal and biomass - were investigated. Examples at multiple scales (utility, community, residential) were collected. Site-specific infrastructure needs at each scale - power, water, transportation, structures, utility needs, constructed components (footings/infrastructure) - and spatial requirements were determined. Also determined were specific element dimensions for modeling.

Figure 22. Representation of 3D models incorporated into a visual presentation of a possible future SEP.

Land Ownership Considerations

West Virginia has a significant advantage in that private ownership of large tracts of land is under coordinated control. This advantage is a basis for the development of one or more energy parks using thousands of contiguous acres. As noted in the identification of potential SEP sites, a closer look at the preliminary 11 sites revealed the sites were primarily controlled by land and coal companies through existing leases. A small minority of sites reviewed were owned directly by the coal company.

Land companies in West Virginia were formed to profit from natural resource extraction. These companies are usually professionally staffed by those experienced in land management. Coal has historically been the primary source of revenue for these companies. It is typical for these companies to have multiple coal leaseholders for each property, depending on size of the tract and numbers of coal seams. Additional leases for gas reserves and timber are common. The rights of the leaseholders created by contract significantly encumber the landowner's rights to the surface of the property and often dictate the current and future use. The lease terms are typically multiple years and often are extended by right based on the continued production of the targeted resource. Leases include the right of the leaser to permit the site under state and federal guidelines. Leases also influence the availability of the surface for alternative land uses.

Research into the surface ownership of the 11 selected sites confirms that most mining operations are centered on a single or core property. In addition to that core tract, a significant number of surface tracts (often in the hundreds) have been assembled, or their mineral rights reserved, and are a part of the mine operation. Careful consideration should be given to the size and strategic location of the core tract as it relates to the concept of an SEP.

There are many considerations by land company managers in regards to cooperating and/or leasing surface rights under an SEP concept. They include the surface owner's legal rights to lease for that purpose, including encumbrances of any current lease term, current mine permitting regulations, and future extraction opportunities.

WVDEP permit mapping was used as a base for this study. Consideration was given to current permitting which can limit surface owners' rights to develop the property for an alternative land use. The sites determined as having priority for these purposes are active mining sites with active leases and mining activity in several stages. These stages can be considered as 1) released from bond, 2) active, and 3) future.

Figure 23 is provided as an example map. The pink areas on the map which represent "unreleased" (bonded) areas under a state mine permit currently have limited surface development rights. These rights are limited both by title and by state mine permitting regulations. The green areas on the maps which represent "released" areas are free from restrictions of the mine permit and bond provided by the mine operator. These areas are more likely available for surface development. Future mine areas are not designated and may only be determined by cooperative discussions with the mine operator or land owner.

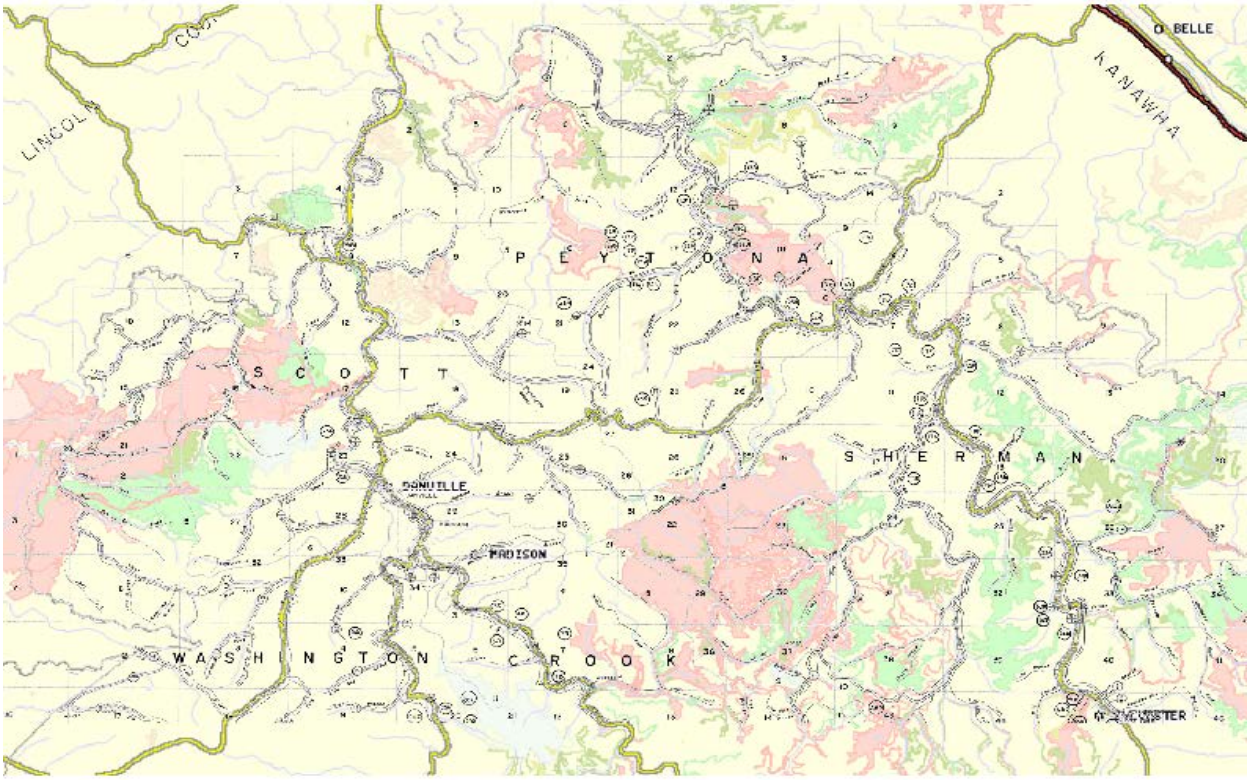

Figure 23. Example map depicting active (pink areas) versus bond-released (green areas) sites in West Virginia.

An exercise was conducted to determine landowners for the preliminary 11 sites. County tax records and personal contacts with large landowners were made. The predominant surface owner(s) were established for each area. A summary of property owners for the eleven sites that were considered can be found in Table 2.

Table 2. Summary of property owners of preliminary top 11 areas considered for SEPs.

Site ID No.	County(ies)	Owner(s)
5	Boone	Southern Land Company and Federal Coal Company (St. Albans, West Virginia); 1,700 acres (majority Southern Land Company); Massey Energy-Laxare and Black Castle
13	Clay/Nicholas	Demeter Land Company, PO Box 1867, Charleston, West Virginia and Nicholas Clay Land and Mineral, 2720 Pennsylvania Ave., Charleston, WV 25302; Massey Energy
18	Kanawha/Fayette	Boone East Development Company, PO Box 271, Julian, WV, 25529; approximately 30,000 acres (largest contiguous area that is bond released); controlled by Massey Energy
20	Kanawha	Shonk Land, 194 Summers Street, Charleston, WV and Penn Virginia Coal Co. and Sidney Polan LLC, Charleston, WV (2,900 acres) and numerous others, including LaFollette, Robson Prichard Trust (all mostly active except for Penn Virginia)

33	Logan	WPP LLC, 5260 Irwin Road, Huntington, WV 25705; approximately 7,000 acres; Massey major leaseholder
42	Logan	Ark Land Company, Allegheny Land Company, City Place One, St. Louis, MO 63141; also United Affiliates Corporation, PO Box 1280 Glenway Avenue, Bristol, TN; 11,000 acrea; Patriot Coal, leaseholder
66	Boone and Lincoln	Southern Land Company (2,500 acres) and Robin Land Company, 500 Lee Street, Suite 900, Charleston, WV (500 acres); and additional 180 additional surface owners (this is the Hobet 21 mine; controlled by Patriot Coal)
96	Mingo	First Bank of Bluefield, PO Box 1559, Bluefield, WV 24701; own 2,288 acres. There are approximately 120 additional surface owners (ICG, leaseholder)
98	Logan	Cole and Crane Real Estate, 848 4th Avenue, Suite 303, Huntington, WV 25701; multiple other surface owners
101	Logan	Ark Land Company, a small amount is Pocahontas Land Company
177	Boone	No predominate surface owner; approximately 240 total surface owners

With the exception of Site ID No. 177 in Boone County, a predominant surface landowner has been identified for each site. Most of these sites are professionally managed. In all areas, there are a number of small surface landowners whose cooperation may or may not be important to a proposed land use plan. In some areas the number of surface owners is very likely to present a challenge to the opportunity for significant development.

The permitting phase of each mine is an important consideration to the opportunity for future surface development. While land area is encumbered by a mine permit, there is very limited opportunity even for access to the property due to liability and safety considerations by the permit holder. Once the WVDEP releases the bond, the property's surface land is available for development under more general development regulations such as county planning and zoning, stormwater management, and state historic preservation regulations, among others.

Land managers of both Southern Land Company (Site ID Nos. 5 and 66) and Penn Virginia (Site ID No. 20) have approved research team member access to their property. Approval from the land companies' Boards of Directors or upper management is necessary and can be pursued should either of these sites draw interest for SEP development.

Site ID No. 18 has the largest acreage of reclaimed land. Another benefit is that the majority of its surface land is controlled or owned by one landowner or leaseholder which, in this case, is the Massey Energy Company (since purchased by Alpha Natural Resources).

This exercise was valuable in determining some "real" world considerations for the site selection criteria. These include:

1. Willingness of surface landowners/leaseholders to consider SEP concept;
2. Large surface land area in relation to few landowners/leaseholders;
3. Surface land not encumbered by future mining or gas well drilling, or already subject to post-mining surface plans;
4. Access/proximity to power plants/power grid;
5. Feasibility of locating small-scale power plants on site;
6. Pre-existing infrastructure that can be used to process/package/transport energy products;
7. Access to rail, major highways, barges;

8. Potable water sources on site; and
9. Time passage since bond release (shorter passage of time equates to less nuisance vegetation).

Chapter 4 - Identification of Potential Sustainable Energy Park Locations

A Geographic Information Systems (GIS) database of potential Sustainable Energy Park (SEP) locations within the state of West Virginia was developed. The final outcome was a listing of potential SEP locations which includes a total of 612 sites with past or present surface mining activity and a minimum size of 100 acres. Various factors related to site suitability were used to evaluate the potential site locations for SEP development.

Figure 24 depicts the number of potential sites by county, based on a minimum size of 100 acres.

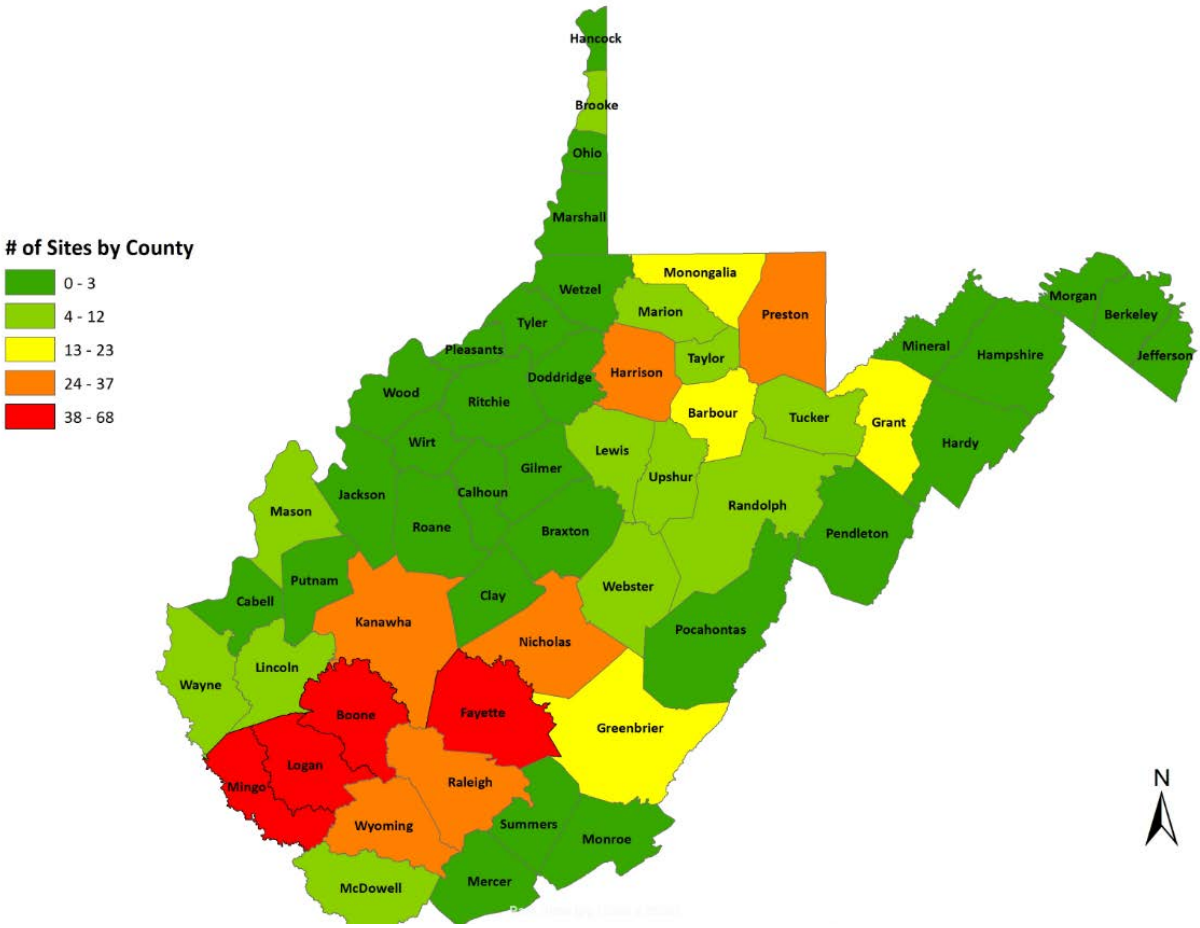

Figure 24. Number of potential SEP sites per county in West Virginia, based on a minimum of 100 surface mined acres.

A site selection methodology was utilized to distinguish potential SEP sites based on simplifying permit data and combining it with West Virginia Geological and Economic Survey (WVGES) mining disturbance data. It was realized that possible sites were being overlooked based on the acreage, e.g., if they were long, narrow tracts of disturbed land. To counteract the oddly shaped permit boundaries and to more accurately project the possible size of land for a SEP, researchers developed a site selection methodology. See Figure 25 for a flow chart diagram depicting the process of developing simplified shapefiles.

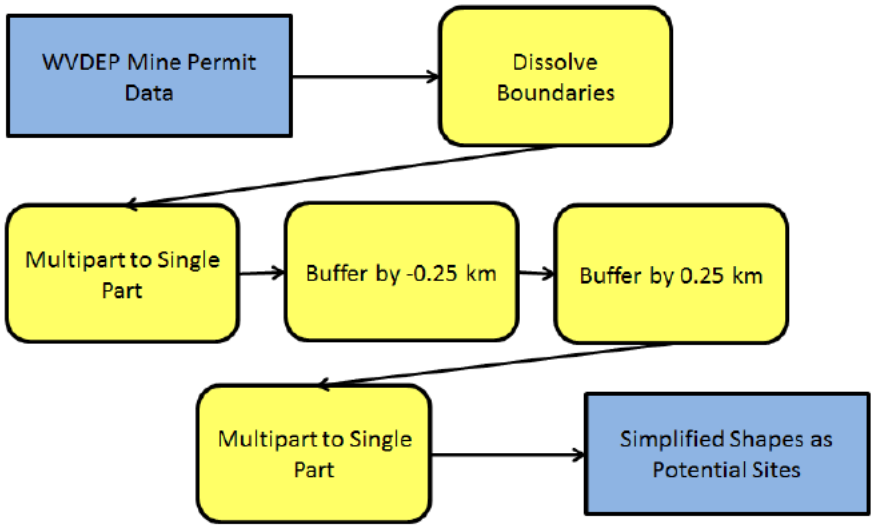

Figure 25. Methodology for simplifying mine features.

The resulting sites are areas larger than 100 acres of mine disturbance. Characteristics include both pre- and post- Surface Mining Control and Reclamation Act (SMCRA) mine lands, regardless of disturbance or land cover conditions. The site selection method produced 612 polygons statewide with an area larger than 100 acres. Area statistics are provided in Table 3. The average size of the sites is 474 acres. As depicted in Figure 26, the majority of these sites are smaller than 1,000 acres. These are the sites that are being analyzed further for their potential as a SEP.

Table 3. Area statistics for resulting features or sites.

Number of Features	612
Minimum Area	100 Acres
Maximum Area	7,536 Acres
Total Area	289,670 Acres
Mean Area	474 Acres

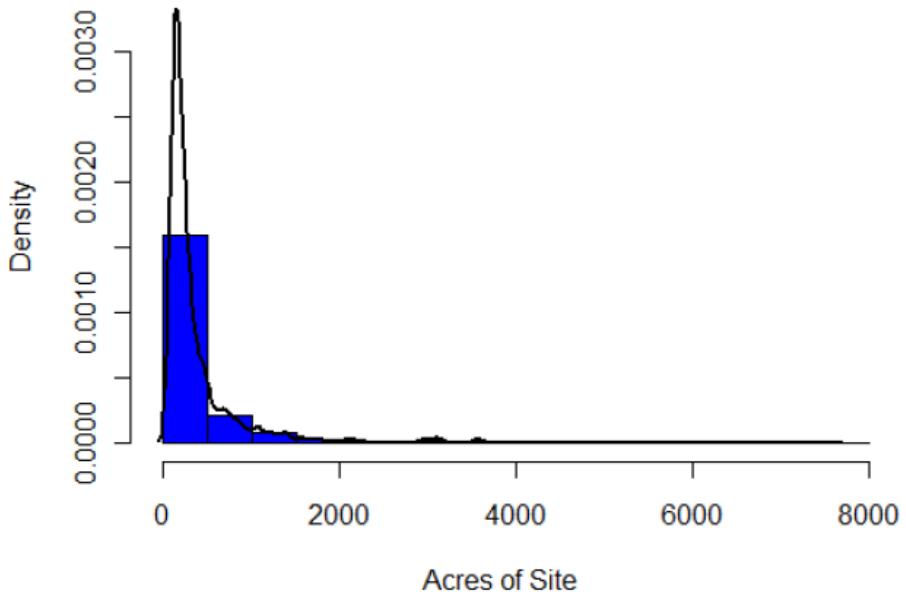

Figure 26. Histogram distribution of site acres.

Additionally, sites are summarized by county. For example, 32 sites intersect the boundary of Preston County, totaling 5,632 acres, while a total of 55 sites intersect Mingo County, totaling 32,577 acres. A summary of the total area of all sites by county is shown in Figure 27. Strictly for demonstration purposes, Figure 28 shows potential sites for Nicholas County and Figure 29 shows the data at a larger scale near Morgantown, West Virginia.

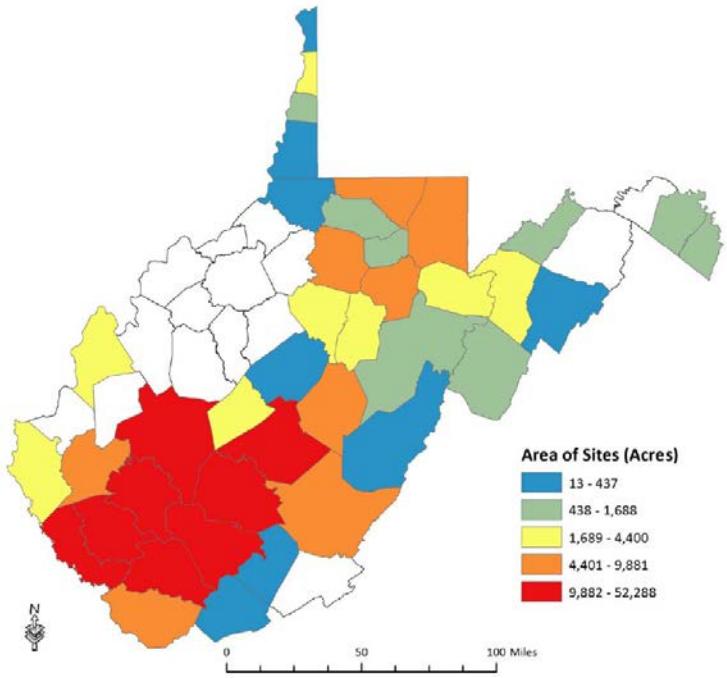

Figure 27. Total area of sites by county considered to be suitable for SEPs based on site selection criteria.

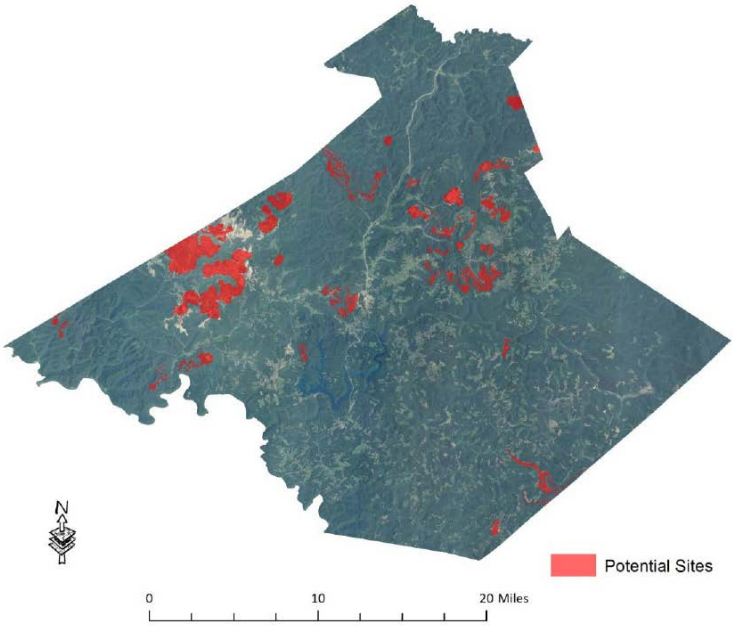

Figure 28. Potential SEP sites in Nicholas County, West Virginia.

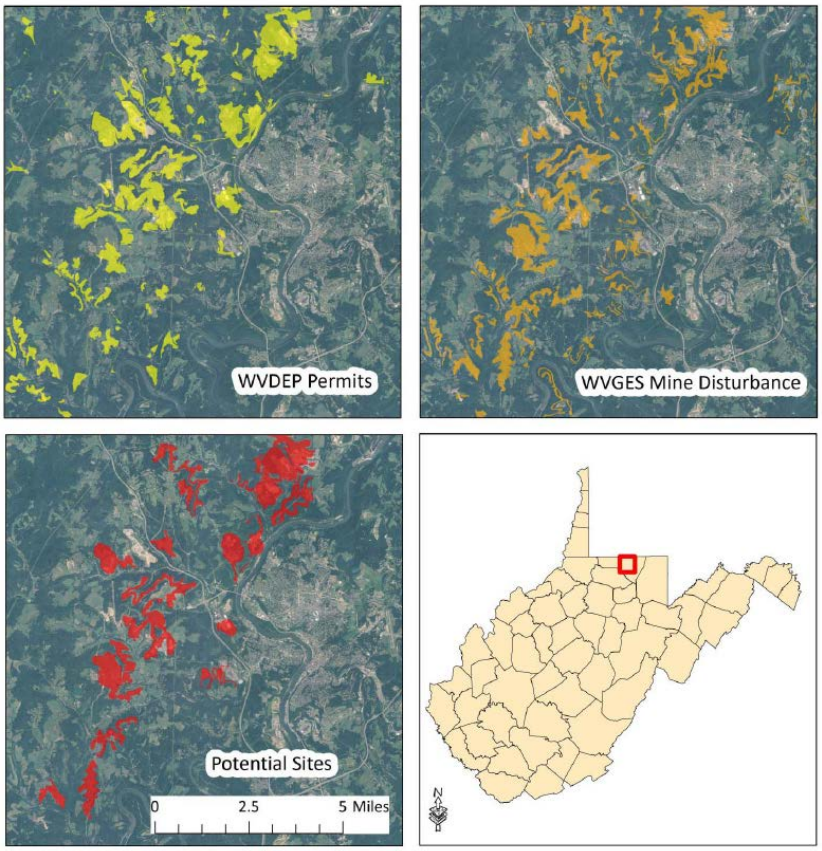

Figure 29. Example of potential sites near Morgantown, West Virginia.

Portfolio of Candidate Sustainable Energy Park Sites

The evaluation of over 15,000 Surface Mine Control and Reclamation Act permits revealed 612 suitable sites. An excerpt of the 612 sites is shown below in Table 4. The full list of sites can be found in Appendix D. Researchers used a matrix to rank the 612 sites based on their relative "alternative energy score" for solar, wind, and biomass.

Table 4. Excerpt showing 300 of the 612 sites identified in the SEP portfolio.

Site ID	Acres of Site	County	Site ID	Acres of Site	County	Site ID	Acres of Site	County
Site 1	307	McDowell	Site 101	653.2	Wyoming	Site 201	200.3	Fayette
Site 2	837	McDowell	Site 102	1112.2	Wyoming	Site 202	168.3	Logan
Site 3	118.2	McDowell	Site 103	151.5	Logan	Site 203	158.1	Fayette
Site 4	338.5	McDowell	Site 104	524	Logan	Site 204	184.8	Fayette
Site 5	395	McDowell	Site 105	872.6	Logan	Site 205	151.4	Boone
Site 6	138.8	McDowell	Site 106	424.9	Logan	Site 206	146.4	Boone
Site 7	978.6	McDowell	Site 107	124	Raleigh	Site 207	100.8	Boone
Site 8	109.4	McDowell	Site 108	2064.1	Mingo	Site 208	417	Raleigh
Site 9	212	Mercer	Site 109	105.6	Logan	Site 209	809	Fayette
Site 10	153.1	McDowell	Site 110	134.1	Boone	Site 210	136.8	Fayette
Site 11	895.2	McDowell	Site 111	134.1	Raleigh	Site 211	193.1	Boone
Site 12	653.5	McDowell	Site 112	2056.1	Logan	Site 212	134	Mingo
Site 13	288.1	McDowell	Site 113	776.3	Logan	Site 213	227.9	Boone
Site 14	259.7	Wyoming	Site 114	412.5	Logan	Site 214	425.4	Boone
Site 15	485	Wyoming	Site 115	149.2	Raleigh	Site 215	105.2	Boone
Site 16	239.7	Wyoming	Site 116	106.8	Boone	Site 216	111.4	Fayette
Site 17	785.4	Wyoming	Site 117	135.8	Boone	Site 217	149.3	Fayette
Site 18	114.5	Wyoming	Site 118	679.7	Mingo	Site 218	164.4	Fayette
Site 19	109.5	Wyoming	Site 119	166.6	Boone	Site 219	238.7	Fayette
Site 20	1571.4	Wyoming	Site 120	307.9	Raleigh	Site 220	171	Fayette

Site ID	Acres of Site	County	Site ID	Acres of Site	County	Site ID	Acres of Site	County
Site 21	323.4	Mingo	Site 121	866.9	Logan	Site 221	3104.5	Boone
Site 22	101.9	Wyoming	Site 122	164.9	Raleigh	Site 222	208.3	Lincoln
Site 23	117.6	Mingo	Site 123	922.8	Logan	Site 223	303.8	Mingo
Site 24	267.7	Mingo	Site 124	317.4	Raleigh	Site 224	104.8	Fayette
Site 25	113.6	Raleigh	Site 125	692.6	Mingo	Site 225	108.2	Wayne
Site 26	255.7	Mingo	Site 126	1410.6	Boone	Site 226	181.5	Fayette
Site 27	312.1	Mingo	Site 127	2895.7	Logan	Site 227	3560.6	Raleigh
Site 28	1235.5	Mingo	Site 128	113.4	Raleigh	Site 228	104.9	Fayette
Site 29	168.5	Mingo	Site 129	180.8	Raleigh	Site 229	142	Fayette
Site 30	566.6	Mingo	Site 130	411	Mingo	Site 230	110.9	Fayette
Site 31	133.5	Raleigh	Site 131	1375.8	Logan	Site 231	661.1	Lincoln
Site 32	341.2	Mingo	Site 132	110.8	Boone	Site 232	134.7	Boone
Site 33	141.3	Raleigh	Site 133	475.2	Boone	Site 233	107.8	Fayette
Site 34	1218.1	Mingo	Site 134	168.4	Mingo	Site 234	258.4	Boone
Site 35	246.1	Raleigh	Site 135	140.8	Mingo	Site 235	234	Fayette
Site 36	1295.9	Mingo	Site 136	357.4	Mingo	Site 236	231.4	Fayette
Site 37	3816.3	Mingo	Site 137	177.2	Mingo	Site 237	274.8	Wayne
Site 38	289.8	Wyoming	Site 138	2639	Logan	Site 238	485.4	Kanawha
Site 39	700.1	Mingo	Site 139	1066.5	Logan	Site 239	190.9	Fayette
Site 40	301.8	Mingo	Site 140	183.5	Boone	Site 240	162.5	Wayne
Site 41	170.9	Mingo	Site 141	141.7	Logan	Site 241	480.5	Boone
Site 42	102.6	Wyoming	Site 142	3032.8	Logan	Site 242	146.2	Fayette
Site 43	105.4	Mingo	Site 143	243.2	Boone	Site 243	1176.7	Boone
Site 44	339.2	Raleigh	Site 144	102.2	Logan	Site 244	2298.1	Kanawha

Site ID	Acres of Site	County	Site ID	Acres of Site	County	Site ID	Acres of Site	County
Site 45	238.2	Wyoming	Site 145	101.1	Fayette	Site 245	104.9	Fayette
Site 46	101.2	Mingo	Site 146	723.4	Mingo	Site 246	114.6	Wayne
Site 47	933.1	Mingo	Site 147	932.9	Boone	Site 247	316.2	Greenbrier
Site 48	189.6	Wyoming	Site 148	246.9	Logan	Site 248	179.5	Boone
Site 49	792.8	Raleigh	Site 149	1693.8	Raleigh	Site 249	108.9	Greenbrier
Site 50	376.9	Mingo	Site 150	234.5	Raleigh	Site 250	295.5	Fayette
Site 51	223.7	Mingo	Site 151	114.4	Boone	Site 251	153	Lincoln
Site 52	193.1	Raleigh	Site 152	215.5	Greenbrier	Site 252	369	Boone
Site 53	168.4	Wyoming	Site 153	117.4	Logan	Site 253	143.3	Boone
Site 54	1034.9	Wyoming	Site 154	140.5	Logan	Site 254	123.3	Fayette
Site 55	159.6	Mingo	Site 155	103.8	Fayette	Site 255	301	Wayne
Site 56	112.7	Mingo	Site 156	1048.4	Mingo	Site 256	385.8	Greenbrier
Site 57	295.2	Logan	Site 157	499.9	Logan	Site 257	256	Wayne
Site 58	101.2	Raleigh	Site 158	113.1	Mingo	Site 258	327	Boone
Site 59	203.7	Logan	Site 159	152.8	Raleigh	Site 259	515.8	Greenbrier
Site 60	332	Mingo	Site 160	152.8	Boone	Site 260	113.7	Greenbrier
Site 61	118.2	Wyoming	Site 161	185.9	Boone	Site 261	858.2	Wayne
Site 62	303.5	Wyoming	Site 162	138	Mingo	Site 262	654.2	Fayette
Site 63	163	Wyoming	Site 163	165.2	Fayette	Site 263	308.2	Boone
Site 64	1837.8	Mingo	Site 164	1387.7	Raleigh	Site 264	816.9	Kanawha
Site 65	1530.7	Mingo	Site 165	207.1	Logan	Site 265	169.3	Boone
Site 66	336	Wyoming	Site 166	172	Mingo	Site 266	270.3	Fayette
Site 67	107.2	Logan	Site 167	114.7	Fayette	Site 267	104.2	Greenbrier
Site 68	221.6	Raleigh	Site 168	233.2	Fayette	Site 268	104.8	Greenbrier

Site ID	Acres of Site	County	Site ID	Acres of Site	County	Site ID	Acres of Site	County
Site 69	233.6	Logan	Site 169	3127.8	Boone	Site 269	126.4	Greenbrier
Site 70	290.4	Mingo	Site 170	2970.1	Logan	Site 270	457.7	Boone
Site 71	509.7	Wyoming	Site 171	205.8	Logan	Site 271	259.7	Greenbrier
Site 72	193	Logan	Site 172	131	Fayette	Site 272	1254.1	Boone
Site 73	1391.2	Logan	Site 173	3604.3	Logan	Site 273	104.2	Fayette
Site 74	341.9	Wyoming	Site 174	120.6	Boone	Site 274	139.9	Fayette
Site 75	115.4	Mingo	Site 175	145.7	Raleigh	Site 275	308.6	Boone
Site 76	133	Raleigh	Site 176	103.3	Boone	Site 276	7536	Boone
Site 77	289.5	Logan	Site 177	107.3	Mingo	Site 277	242.5	Greenbrier
Site 78	569.8	Wyoming	Site 178	1798.5	Logan	Site 278	466.7	Boone
Site 79	113.3	Logan	Site 179	116.6	Boone	Site 279	2477.1	Fayette
Site 80	263.7	Logan	Site 180	776.6	Boone	Site 280	159.5	Boone
Site 81	322.2	Logan	Site 181	105.2	Fayette	Site 281	315.3	Kanawha
Site 82	267	Logan	Site 182	179.7	Raleigh	Site 282	143.4	Greenbrier
Site 83	220.9	Greenbrier	Site 183	154.2	Fayette	Site 283	558.1	Fayette
Site 84	1522.4	Logan	Site 184	444.8	Mingo	Site 284	460.9	Fayette
Site 85	226	Logan	Site 185	481.1	Fayette	Site 285	4839.2	Boone
Site 86	108.2	Mingo	Site 186	650	Boone	Site 286	100.4	Greenbrier
Site 87	115.3	Wyoming	Site 187	147.1	Fayette	Site 287	107.7	Fayette
Site 88	216.7	Mingo	Site 188	111.8	Fayette	Site 288	114.9	Fayette
Site 89	146.3	Raleigh	Site 189	3530.7	Raleigh	Site 289	170.7	Greenbrier
Site 90	412.5	Wyoming	Site 190	101	Boone	Site 290	243.5	Kanawha
Site 91	105.7	Mingo	Site 191	753.1	Raleigh	Site 291	3137.8	Lincoln
Site 92	268.4	Mingo	Site 192	102.9	Fayette	Site 292	302.3	Greenbrier

Site ID	Acres of Site	County	Site ID	Acres of Site	County	Site ID	Acres of Site	County
Site 93	390.1	Wyoming	Site 193	200.6	Boone	Site 293	529.2	Fayette
Site 94	263.2	Logan	Site 194	307.9	Raleigh	Site 294	185	Kanawha
Site 95	115.1	Mingo	Site 195	6309.6	Boone	Site 295	168.2	Nicholas
Site 96	509	Logan	Site 196	1613.7	Logan	Site 296	578.3	Greenbrier
Site 97	269.3	Wyoming	Site 197	231.4	Mingo	Site 297	826.6	Lincoln
Site 98	554.4	Logan	Site 198	312.9	Raleigh	Site 298	493.3	Boone
Site 99	756.4	Logan	Site 199	165.8	Boone	Site 299	121.5	Greenbrier
Site 100	501	Logan	Site 200	596.3	Boone	Site 300	5219.3	Boone

Chapter 5 - Prioritization Tool

Purpose

Researchers developed a site selection criteria matrix, the Prioritization Tool, using Microsoft Excel® in which production estimates of biofuels, wind turbines, and solar panels on mined lands can be calculated and used as guidance in the proposed design of Sustainable Energy Parks (SEPs) (see Tables 5 through 7 below). This matrix includes the following criteria which have been identified as being important contributors to the development of SEPs:

- Cost inputs
- Energy outputs
- Land inputs
- Biomass
- Wind
- Solar

The research team created the Prioritization Tool (*hereinafter referred to as, the Tool*) for community members, local and state officials, energy and property developers, land- owners, mine operators, entrepreneurs, and other stakeholders to qualitatively and quantitatively classify and evaluate properties using identified screening criteria to establish their potential as SEPs. The Tool is intended to be used early in the SEP planning process to provide an initial level of site screening that will spur conversation between all stakeholders interested in placing wind, solar, or biofuels on sites within the Appalachian region.

The Tool was created in a Microsoft Excel® spreadsheet and was chosen due to its widespread availability and user-friendliness. The goal with this choice was to include users from a wide range of technical abilities.

Goals and Objectives

The primary goals and objectives of the Tool will benefit many types of stakeholders. The Tool is designed to:

1. Highlight, collect, bridge data gaps, and organize crucial and initial site characteristics and energy data.
2. Determine threshold criteria and market values for each energy type.
3. Develop a standard consistent set of data among all candidate properties to aid in evaluating top sites.
4. Select potential properties for SEP consideration.
5. Display the feasibility of each sustainable energy type per site.
6. Evaluate potential scenarios of implementing sustainable energy technologies.
7. Provide common ground between developers and communities through a complete data set that provides potential SEP properties.
8. Enable communities to attract interested energy developers.

Background

Initially, the Tool included more than 30 site selection criteria based on site characteristics to determine the viability for solar, wind, or biofuel production. Numerical values and percentages for all site characteristics were extracted for each of our 612 Candidate SEP sites through GIS analysis of existing spatial datasets.

Upon further research, the team decided to use only the screening criteria and threshold site characteristics from the United States Environmental Protection Agency (USEPA) and National

Renewable Energy Laboratory (NREL) screening sites for wind energy potential (Table 5), screening sites for solar photo voltaic (PV) potential (Table 6) and the biofuels screening criteria' documents (Table 7) below.

Table 5. Wind screening criteria and market values tab within the Prioritization Tool.

Wind Screening Criteria and Market Values		
Wind Resource Potential	5.5	m/s @ 80m
Minimum Available Land (Ridgetops)	2	Acres
Distance to Transmission Lines	1	Mile(s)
Distance to Nearest Road	1	Mile(s)
Wind System Cost	$3,000.00	$/kilowatt

Table 6. Solar screening criteria and market values tab within the Prioritization Tool.

Solar Screening Criteria and Market Values		
Solar Resource Potential	3.5	kWh/m2/day
Minimum Available Land (Solar)	2	Acre(s)
Distance to Nearest Road	0.5	Mile(s)
Distance to Graded Road	1	Mile(s)
MW Generation Potential	5	Acres/MW
PV System Cost	4.50	$/watt

Table 7. Biofuels screening criteria and market values tab within the Prioritization Tool.

Biofuels Screening Criteria and Market Values		
Minimum Available Land (Biofuels)	10	Acre(s)
Distance to Nearest Processing Facility	150	Mile(s)
Distance to Nearest Road	5	Mile(s)
Biofuel Yield	4	tons/acre
Biofuel Production Costs	171.42	$/acre
Biofuel Value	60	$/ton

The NREL documents provided the researchers with the crucial screening criteria and threshold values that could be used to determine a "yes" or "no" viability and basic financial information for each energy type on any site. Extracted from the NREL documents, three to four screening criteria with threshold values per energy type are incorporated in the Tool's formulas to determine the potential or absence of energy per site. The NREL Screening Criteria was also seen by the researchers as a recognized technical "brand" which would be accepted by potential investors. While the NREL screening criteria does not guarantee site viability, it provides an equal analysis to compare sites in other states and across regions.

Prioritization Tool Use

The Tool, which was designed in Microsoft Excel®, has multiple tabs that allow users to input or update screening criteria, site characteristics, and market values. Once these values are successfully entered into the Screening and Market Inputs tab and Site Characteristic Input tab, the Tool will automatically populate the output tabs. The data output tabs include: Biofuel Outputs, Solar Outputs, and Wind Outputs. The outputs will provide users with results on whether particular properties have the potential for that energy type, the quantity of energy production per site, and financial outputs and values of each site (see Tables 8 through 10 below).

Once most or all of the site data is collected, a community will then have a package of data for their potential properties that can be used to approach and solicit investors and developers. Communities will also be able to minimize time spent on properties that have little to no potential for sustainable energy development. Communities that present this robust initial package of data to energy developers will be ready to engage in meaningful dialogue with established energy developers. The community will also have completed a significant portion of upfront data collection, which will save developers' time, energy, and financial investment.

The research team has created a Prioritization Tool Handbook to help users understand how to use the Tool. The Handbook provides more detail on the tabs, data to input, where to locate data, which values may need updated periodically, and other crucial aspects to the Tool. The Handbook is located in Appendix E.

Table 8. Biofuel Outputs tab within the Prioritization Tool.

Biofuel Outputs								
Parcel ID	Available Land (Biofuel)	Distance to Nearest Road	Distance to Nearest Processing Facility	Biofuel Possible?	Yield	Production Costs ($/acre)	Production Costs ($/ton/acre)	Total Value per site
1	0	10.71	0.00	No				
2	193.483	10.66	0.00	No				
3	0.222	14.28	0.85	No				
4	40.253	12.90	0.93	No				
5	53.152	15.11	1.07	No				
6	43.589	9.67	1.10	No				
7	196.819	14.78	1.90	No				
8	8.006	14.95	0.60	No				
9	98.965	2.30	3.07	Yes	395.86	$ 16,965	$ 4,241	
10	8.451	16.14	0.38	No				
11	2.446	14.46	0.00	No				

Table 9. Solar Outputs tab within the Prioritization Tool.

Solar Outputs								
Parcel ID	Solar Resource Potential (kWh/m2/day)	Available Land (Solar)	Distance to transmission lines	Distance to Nearest Road	Solar Possibile?	MW Potential	PV Installation Cost	Value Per Site
471	6.25	4.22549	1.807902272	4.146269767	No			
472	4.68	34.9159	0	2.440270665	No			
473	5.96	11.5645	0	2.610057199	No			
474	4.60	48.0371	0	9.293415058	No			
475	4.64	2.22394	0.021203112	0.021850567	Yes	0.44	$ 200,154.60	
476	6.60	18.0139	2.624254157	4.955871907	No			
477	4.65	26.9097	0.673350165	4.692858982	No			
478	4.25	2.89112	10.9551612	8.854837419	No			

Table 10. Wind Outputs tab within the Prioritization Tool.

Wind Outputs														
Parcel ID	Wind Resource Potential (m/s @ 80m)	Available Land (Wind)	Distance to transmission lines	Distance to Nearest Road	Wind Possible?	# of turbines/site (Small)	# of turbines/site (Mid)	# of turbines/site (large)	MW Potential (Small)	MW Potential (Mid)	MW Potential (Large)	System Price (small)	System Price (mid)	System Price (large)
451	6.73133	55.28	5.690731908	12.83168662	No									
452	4.63411	52.68	2.53373337	7.216335394	No									
453	7.32521	36.91	6.220224831	12.83168662	No									
454	4.41584	387.40	0	3.516972965	No									
455	6.14567	99.58	0	0.841449264	Yes	77	15	9	8	13	19	$ -	$ -	$ -
456	4.66006	93.07	2.24480753	6.229822747	No									
457	6.99881	21.84	6.639188578	12.83168662	No									
458	4.9193	103.48	2.345507607	1.425708657	No									

Chapter 6 - Community Engagement, Education, and Training

In an effort to educate communities about Sustainable Energy Parks (SEPs) and the research to be conducted, a press release regarding the receipt of the United States Environmental Protection Agency (USEPA) award was released on September 13, 2008. To draw additional attention to the project, a check presentation with representatives from USEPA, West Virginia Department of Environmental Protection (WVDEP), and West Virginia Water Research Institute (WVWRI) was held at the September 2008 West Virginia Brownfields Conference in Huntington, West Virginia.

Researchers engaged, educated, and trained communities on the potential for redeveloping former mine lands into SEPs. The following describes the various ways communities were engaged throughout the duration of the project.

Conceptual Drawing

In order to better explain the concept of SEPs, the project team created a "vision" through the development of conceptual drawings, digital imagery, and GIS mapping. The vision was used to help educate communities and others about the different possibilities available for economic development, as well as a more tangible idea of the types of development that could occur on mine-scarred lands (Figure 30). A Masters level Graduate Research Assistant served as a graphic artist and was also educated on the concept of SEPs through his work on developing the graphic model.

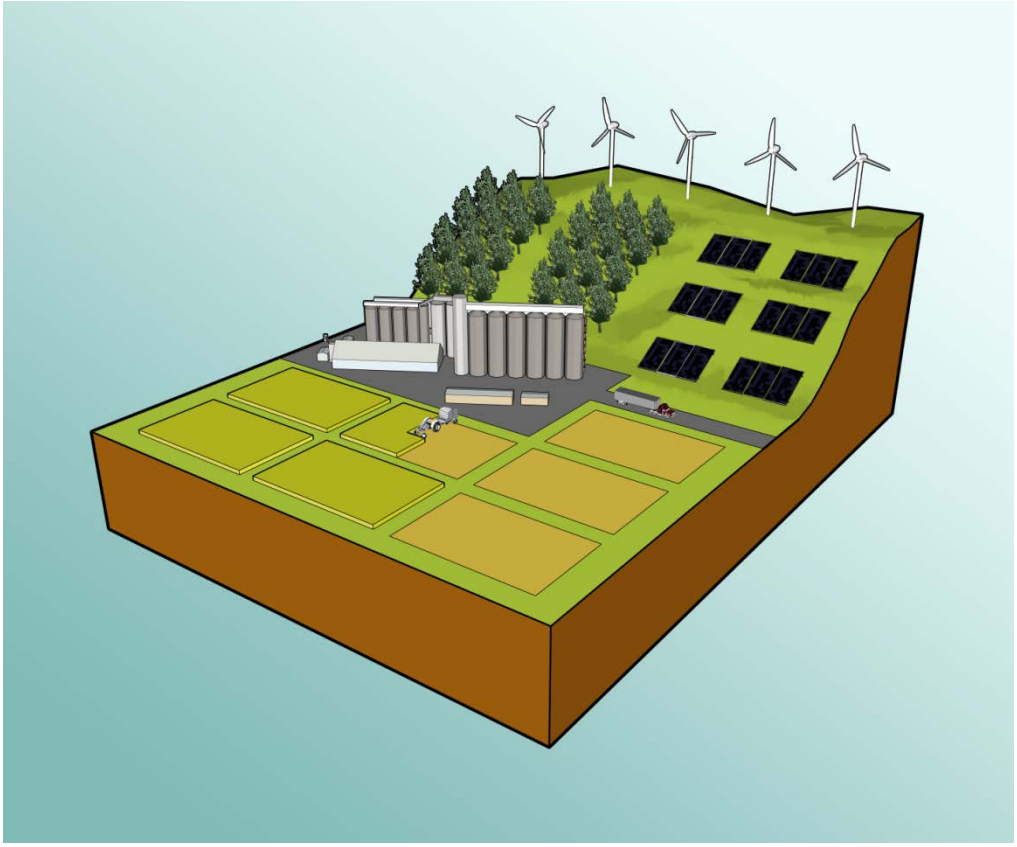

Figure 30. Example image of SEP conceptual drawing.

Project Fact Sheet

An informational fact sheet on the project was distributed to 33 counties that are required by the West Virginia Division of Energy to have Land Use Master Plans for former surface mine sites. The fact sheet included the conceptual graphics and was placed on the project web page (Appendix F).

Project Flyer

A flyer on the project and concept of SEPs for distribution to citizens and local government officials was developed and reviewed by USEPA (Appendix G). Researchers also distributed the flyer at the National Brownfields Conference in Philadelphia, Pennsylvania in April 2011. The flyer was used primarily as an informational tool when engaging citizens, county commissioners, and development authorities in considering SEPs in their communities.

Meetings with Local Government

Presentations

Researchers presented information on mine-scarred lands as brownfields and the SEP concept at the following venues:

West Virginia Economic Developers Council Annual Meeting
September 21, 2010
Hedgesville, WV
Audience: Economic Development Authority Directors from all 55 counties

Regional Planning and Development Council Conference
September 22, 2010
Shepherdstown, WV
Audience: Regional Planning and Development Directors and staff from across the entire state

Meetings

Lewis County Economic Development Authority
Locally, project staff met with Economic Development Authority Director for Lewis County, Doug Parsons, on November 19, 2010 to discuss the reuse of mine-scarred lands. During the meeting researchers discussed opportunities for the mine-scarred lands, including landowners that may be open to SEPs as a redevelopment option. Researchers also discussed approaching the County Commission in the spring to gauge their interest. Currently Lewis County is experiencing a boom in demand for industrial property related to the Marcellus Shale natural gas drilling industry. This made receiving property owner "buy-in" unviable.

Regional Planning and Development Council's Annual Meeting
Researchers gave a presentation at the Regional Planning and Development Council's Annual Meeting on May 18, 2011 held in Wheeling, West Virginia. Researchers discussed the possibilities of SEPs in the context of regional planning and economic development efforts.

Statewide Land Use Master Plan Meetings
The State of West Virginia requires each County with current or former surface mining activities to have a Land Use Master Plan (LUMP). In May 2011 researchers continued to work with County commissions and county economic development agencies on land use master planning efforts of mine-scarred lands; specifically, with Marion, Taylor and Tucker counties.

The purpose of the LUMP is to provide guidance and suggestions for alternate land uses of transportation systems, highway development, and surface mine sites. Based on interaction with WVDE, SEPs on post-mine land sites are identified as a priority in each county's LUMP. These plans

build the foundation and offer an opportunity for the county to engage its citizens regarding opportunities to develop SEPs. In total, 13 counties in northern West Virginia have completed their county-specific LUMPs: Barbour, Brooke, Grant, Harrison, Marion, Mineral, Monongalia, Ohio, Preston, Randolph, Taylor, Tucker, and Upshur Counties. Based on a meeting in December, 2011 with the Southern Brownfields Assistance Center, all of the southern coalfields communities were made aware of the SEP opportunity.

Training Workshop for West Virginia University County Extension Agents
WVU Extension, which coordinates training and provides oversight to the State County Extension Agents, was contacted in October 2009 regarding a training workshop for Extension Agents to understand SEP concepts and potential to utilize switchgrass as a biomass crop for fuel/energy.

WVU Extension Professional Development Days Short Course
A course on SEPs and alternative energies was held at the 2010 WVU Extension Professional Development Days. The presentation at the training was geared toward the basics of SEPs as a viable opportunity for public and private sector involvement in the agents' assigned communities. The details of this course are below.

WVU Extension Professional Development Days Short Course
September 23, 2010
Jacksons Mill, WV
Audience: County Extension Agents

K-6 Report
At USEPA's request, SRA International provided the research team with a draft write-up on the project. SRA International, a subcontractor to USEPA, was assigned to summarize EPA-funded projects for a K-6 report and asked that the draft write-up be reviewed. Researchers reviewed the draft and sent suggested edits to SRA International.

Web Portal
The project team developed a web portal as a platform to share information about the project. A webpage was created, http://wvwri.nrcce.wvu.edu/bf09.cfm, to share fact sheets, request for proposals, conceptual images and other information on the project. An e-mail address, sustainableenergyparks@mail.wvu.edu was also secured for correspondence purposes. This e-mail was used for submission of the RFP from communities.

Chapter 7 - Selection of a Pilot Sustainable Energy Park Site

Request for Proposals

To test the Sustainable Energy Park (SEP) Model, a pilot SEP location needed to be identified. The location of the pilot site is important for the physical characteristics, technical compatibility, environmental conditions, and subsequent economic feasibility. Other essential components are the social variables such as project support from the community, local government, and economic development organizations. Perhaps the most important component is landowner buy-in.

To ensure that the pilot site would possess as many of the technical, environmental, economical, and social attributes as possible, the selection of the pilot site was posted as a Request for Proposals (RFP) opportunity to all West Virginia counties with post-mine lands. A draft RFP for a feasibility plan for SEPs at the community level was developed and sent to the following for review:

- Patricia Corbett, Project Manager, United States Environmental Protection Agency (USEPA) Region III
- Ken Ellison, Director, West Virginia Department of Environmental Protection (WVDEP), Division of Land Restoration
- Jeff Herholdt, Director, West Virginia Division of Energy (WVDE)
- Geary Weir, Executive Director, Webster County Economic Development Authority
- George Carico, Economic Development Specialist, Southern West Virginia Brownfields Assistance Center, Marshall University
- Rachel Lester, Director, Office of Coalfield Community Development (OCCD)
- Tamara Vandivort, Associate Director, West Virginia Water Research Institute

Comments on the draft RFP were received and incorporated into the final RFP (Appendix H).

The SEP Request for Proposals (RFP) was released statewide on November 14, 2011, to solicit communities interested in participating as the pilot site for testing the SEP Framework. The release was sent out via e-mail to the Economic Development Authority (EDA) in each county, to all 11 Regional Planning and Development Councils (RPDCs), as well as to a listserv of over 1,000 brownfields constituents in the state.

To identify additional potential respondents to the RFP, SEP researchers met with the WVDE Office of Coalfield Community Development (OCCD), and Marshall University's Center for Environmental, Geotechnical and Applied Sciences (CEGAS) on December 15, 2011, to discuss potential renewable energy sites on former surface mine property and the associated contacts in those counties/communities. The OCCD committed to distributing the RFP and educating coalfield communities about the opportunity of incorporating SEP development into the legislatively-mandated Land Use Master Plans.

RFP Announcement

Announcements for the RFP were placed on the West Virginia Water Research Institute website (www.wvwri.org), and the Northern West Virginia Brownfields Assistance Center website (www.wvbrownfields.org), and on listserves. The RFP and the project were announced at the West Virginia Redevelopment Collaborative Event on December 2, 2011, and the 2011 Energy Summit on December 6, 2011. The announcement was also included in brownfields e-newsletters regularly released by the Northern West Virginia Brownfields Assistance Center.

Coordination with Land Use Master Plans

Researchers engaged the West Virginia Division of Energy (WVDE) as a project partner to assist with dissemination of information regarding the SEP RFP. The WVDE agreed to encourage each coalfield

county, defined as a county with post-surface mine lands, to be provided with the information on SEPs as part of their state code required Land Use Master Plan (LUMP) development.

Community Meetings

An exercise to engage community stakeholders to be used at public meetings was developed (Appendix J). Community meetings were held in counties that applied for the RFP and/or showed interest in pursuing renewable energy projects on former mine land.

Proposal Development Briefings and Workshops

Briefings

To encourage applications for the SEP Request for Proposals (RFP) the project team held briefings with Economic Development Authorities (EDAs) and interested alternative energy businesses. The briefings consisted of a review of the SEP concept, sharing the information and documents that were developed by the research team, and a discussion of the potential of the participating county and how that EDA could engage stakeholders. The briefings took place either in person or by telephone at the request of the EDAs. EDAs included Preston, Webster, Grant, Marion, and McDowell Counties.

Workshops

A proposal development workshop was held January 6, 2012, with the Grant County EDA, the Region 8 Planning and Development Council, and interested energy developers (US Wind Force) to review the RFP and tour potential sites of interest. ArcGIS Explorer® online maps created by SEP researchers were used during the workshop to examine site characteristics, property owner questions, and energy infrastructure. A visualization presentation (Appendix I) created by SEP team researchers was used to educate local stakeholders on how the project would appear visually. A workshop was also held for the Webster County Economic Development Authority on January 30, 2012.

SEP researchers met with two county economic development authorities (Marion and Randolph counties) to provide project information and education, and to discuss potential sites.

Interested renewable energy investors and renewable energy installation, production or distribution companies were engaged to connect with communities with existing renewable energy projects in order for the SEP project to build upon the community capacity for renewable energy already built through previous education efforts related to wind, solar, or other technologies. The interested groups include US Wind Force, Potomac Energy Fund, World Construction Group, GroSolar, mtvSolar.

Administer Participatory Planning with Officials and Experts

Alternative energy experts were engaged to provide a practical critique of project design when conceptual designs are completed. Researchers met with West Virginia regional solar energy experts (mtvSolar) to discuss collaboration and review of solar infrastructure design. Researchers met with US Wind Force to discuss wind infrastructure design. These two industry representatives, as experts in their respective fields, will be able to offer significant critiques when the site design is ready for commercialization and plan implementation. Other experts, with the Center for Environmental Geotechnical and Applied Sciences (CEGAS), and the WVDEP Division of Land Restoration (DLR) were engaged to assist in understanding the background on other alternative energy initiatives in West Virginia and to discuss state-specific policy issues regarding abandoned mine site re-use. Additional participatory planning was conducted through meetings with local officials within the communities which responded to the RFP for the development of a SEP.

Review and Selection of Pilot Site

The goal was to select one community with a former surface mine site that meets selection criteria for the creation of a comprehensive SEP development plan for that site. Steps in the proposal review and selection process were as follows:

1. Identify reviewers.
2. Collect proposals from applicants.
3. Disseminate proposals to reviewers.
4. Reviewers rank and select potential project(s).
5. Submit recommended project to USEPA for consideration.
6. USEPA confirms selected community.
7. Applicants notified of results.

1. Reviewers

The selection committee included:

- Ken Ellison, Director, WVDEP - Division of Land Restoration
- Brady Gutta, Project Manager, National Mine Land Reclamation Center
- Patrick Kirby, Director, Northern WV Brownfields Assistance Center
- Paul Ziemkiewicz, Director, West Virginia Water Research Institute
- Tamara Vandivort, Associate Director, West Virginia Water Research Institute

2. Proposals Received

Two proposals were received by the January 31, 2012, due date in response to the RFP. Community site candidates included the following:

1. Mountain Top Industrial Park site in Grant County (Figures 31 and 32) submitted by the Grant County Development Authority, and
2. Indian Ridge site in McDowell County (Figures 33 and 34) submitted by the McDowell County Economic Development Authority.

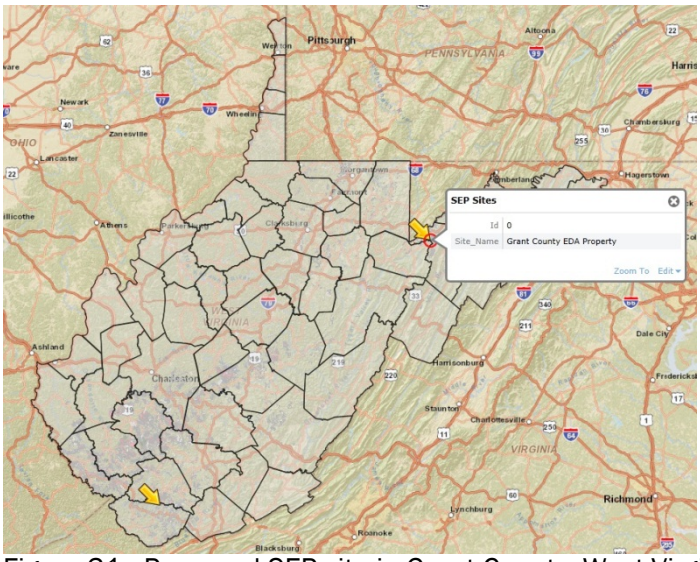

Figure 31. Proposed SEP site in Grant County, West Virginia.

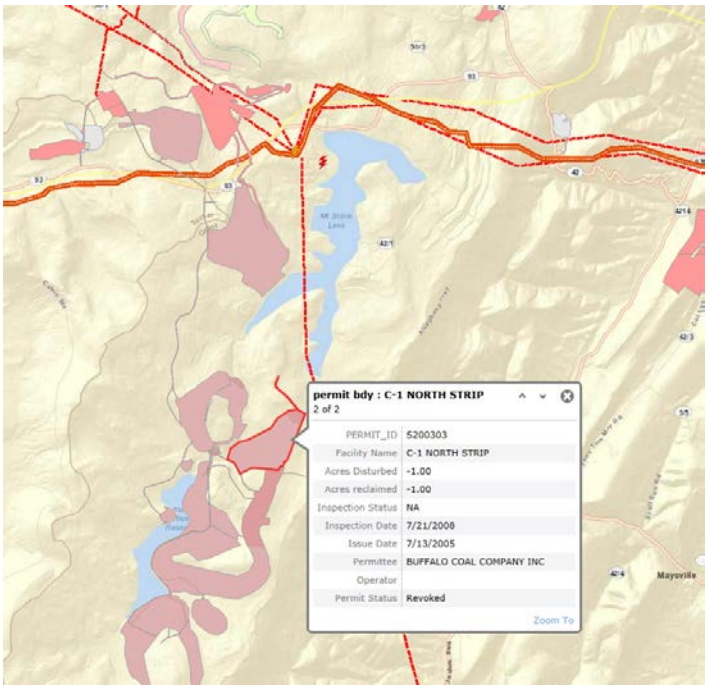

Figure 32. Detailed view of proposed SEP site in Grant County, West Virginia.

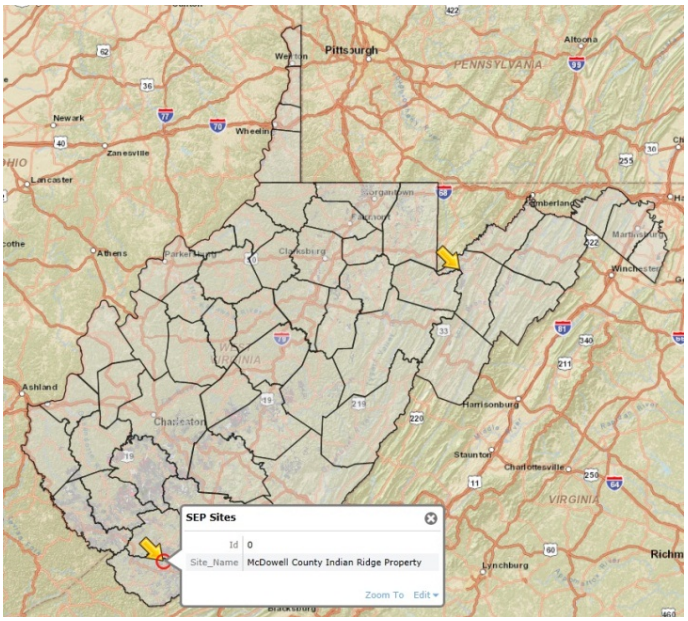

Figure 33. Proposed SEP site in McDowell County, West Virginia.

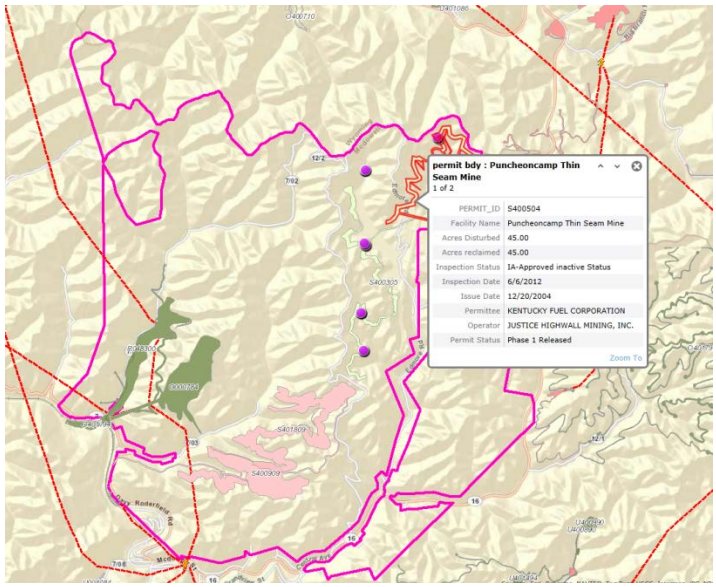

Figure 34. Detailed view of proposed SEP site in McDowell County, West Virginia.

3. Disseminate Proposals to Reviewers

The evaluation criteria used to select the top applicant included four primary categories: 1) Applicant eligibility, 2) site characteristics, 3) applicant capacity, and 4) an overall score.

Site characteristic qualifying questions included slope suitability for switchgrass, potential acreage for biofuel stockpiling, existing infrastructure, proximity to potential markets, accessibility for assessments, and potential for wind, solar and geothermal energy. The applicant capacity qualifying questions included the presence or absence of clear community vision and involvement, a good description of SEP connection with community initiatives, strong stakeholder support, letters of support, perceived ability to sustain project momentum, community's future capacity to redevelop brownfield sites, and other capacity and experience considerations. The land ownership considerations were also used as part of the selection criteria of the pilot SEP proposals, with more value being placed on a single owner (less complicated owner structure). The overall scoring questions involved the application strength and reviewers' interest in working on the applicant's project.

In order to aid the RFP application review process, a series of county and site-level map products intended for site comparison and evaluation were developed. Map products developed included general location maps, recent aerial photography, elevation/contours, slope, existing infrastructure, potential wind energy resources, potential solar energy resources, and any current mining permits or activities for the two proposed sites.

4. Rank and Select Potential Projects

On February 27, 2012 the SEP RFP Selection Committee met to review the two proposals received from the McDowell and Grant County EDAs. The agenda for the selection committee meeting included time to discuss the project backgrounds, project status updates, evaluation questions and RFP process inquiries, the actual review of the evaluation forms, and questions and discussion about the project applications.

Both sites had pros and cons that were closely evaluated. The McDowell County site pros included its large contiguous area, the EDA's ownership and site control, its known solar

rating, sufficient access road, and its adjacent proximity to a Federal Correctional Institute that could likely be an end user of alternative energy. However, the McDowell County site scored low on location and distance from established large energy markets and population centers.

The Grant County site scored high on proximity to already-established wind resources, tangible private sector partnership, and known excess capacity for alternative energy in the area based on permitting, significant energy infrastructure investment nearby, and location to population centers such as Washington, DC. However, the site scored low in these areas: property not contiguous, multiple owners of the site, and the applicant only owned small percentage of the project area at the time of application submission.

Once the discussion and review was complete, the McDowell County EDA was the selected applicant for the pilot SEP.

The McDowell County Economic Development Authority (MCEDA) is the owner of the pilot site identified as "Indian Ridge." The MCEDA is not responsible for contamination and/or environmental conditions related to the surface mining activity that led to the property's current "mine-scarred land" condition. The MCEDA expressed their interest, via their response to the SEP call for proposals, in redeveloping the site and/or entering into a sale or lease agreement for the purpose of the site's redevelopment.

5. Submit Recommended Project to USEPA for Consideration.
USEPA was notified of the two proposals received, the recommendations of the reviewers, and the selection outcome.

6. USEPA Confirms Selected Community
USEPA approved the selection of the Indian Ridge site in McDowell County.

7. Applicants Notified of Results
The McDowell County EDA was notified that their site was selected as the pilot SEP. A meeting for the project researchers to meet with community project stakeholders was arranged. The Grant County applicant was notified that while their site was not selected for the pilot SEP, that staff with the Northern West Virginia Brownfields Assistance Center would continue to work with the community to assist them in achieving their goals.

Chapter 8 - Comprehensive Development Plan

The Comprehensive Development Plan Section illustrates conceptual and programming options based on the Detailed Site Assessment, Business and Marketing Plans, and the Sustainable Energy Park (SEP) Comprehensive Land Use Master Plan.

Site Assessment

Field reconnaissance, soil and water sampling, data review, spatial analysis, and 3-D modeling were utilized to perform a detailed site assessment of the selected SEP Pilot Indian Ridge Site, north of Welch, in McDowell County, West Virginia. Existing GIS data was used to perform analysis of site opportunities and constraints, including a digitized property boundary layer of the McDowell County site (Figure 35). Site coordinates, photos, and spatial extents were easily shared throughout the various project partners via ArcGIS® Online.

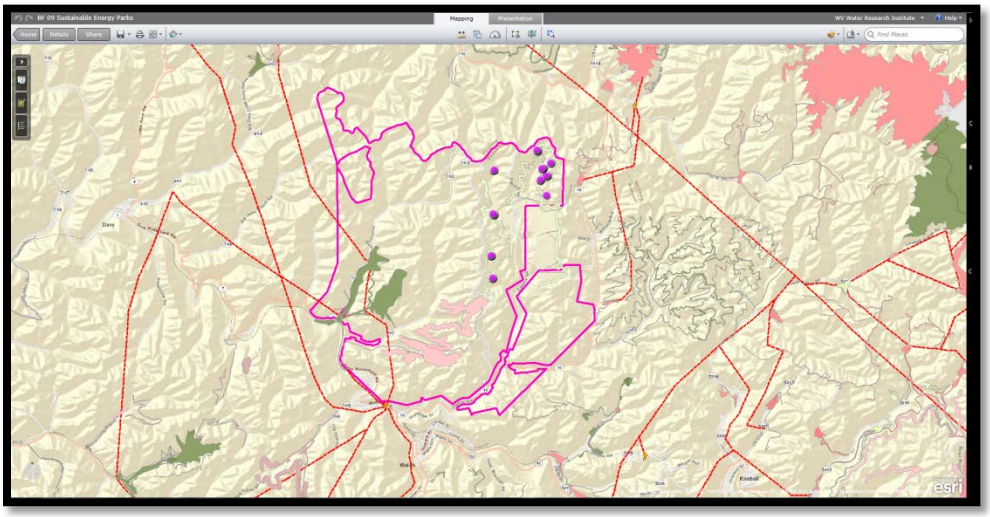

Figure 35. Boundary of potential SEP site in McDowell County, West Virginia.

General Overview

The selected SEP site at Indian Ridge in McDowell County, West Virginia can be described as a site exhibiting scars from former surface mining operations. Highwalls remain in place and surround the site, exposing layers of geological development. The forest perched on the highwalls is a mixture of mature hardwood species with a thin soil profile. The mine scared land contained within the highwalls is generally comprised of highly compacted soil, with several rocky, gravely berms and minimal topographic change beyond the valley fill areas. A utility corridor along the future highway right-of-way bisects the site, creating a ridge separating site hydrology. The vegetation can generally be described as successional, comprised mainly of grasses and forbs with pioneer tree species that are both native and invasive. Grading directs stormwater through a series of swales along the highwall edges and surrounding valley fill areas. Several small isolated wetland pockets have formed in flatter areas throughout the site. There are several valley fill areas as evidenced by patches of mature forest and grassy terraces with stone weirs directing water to the remaining valley reaches. The valley fill slopes are extremely steep making them difficult to access and susceptible to erosion. A series of ponds line the bottom of the valley fill. These areas have limited water movement, acting similar to a detention system. The hydrology here is linked and discharges into the adjacent residential valley. Due to the limited soil profile development, excessive soil compaction, and sparse native vegetation, the site is void of significant ecological value and feeds the adjacent valley with an excess of sediment.

Soils

Soils data provides planners with very important information to guide their planning and design process. Soils provide opportunities and limitations for site development. Specific soils support unique plant communities. Soil stability is also an important consideration when siting structures, trails, and other potential design elements.

The majority of soils on the site can be characterized as compact rocky, gravely oxidized grey to black silt loam mix. Based on the soil and vegetation quality, there is no evidence that topsoil was salvaged and spread following mining operations. This, in conjunction with excessive soil compaction has significantly inhibited healthy soil development. Typically, it can be expected that a gravel/silt loam soil mix would allow for some infiltration. However, due to excessive soil compaction, it is anticipated that there will be little permeability in many areas of the site. Soil pH measurements ranged from 4.0 - 7.2. With all but one measurement being below 7.0, the soils may be characterized as acidic. The dominance of broomsedge bluestem (*Andropogon virginicus*) is further evidence that the soils are acidic with low fertility.

Flat topography in areas surrounding valley fills result in the formation of several wetland pockets. Runoff that is not managed through the swale system settles in these depressions where a hydric soil profile, high in organic content has developed. Even during the dry season these soils remain saturated, with a high clay content and show very little evidence of oxidation. There are some wetland areas receiving higher afternoon sun that were drier in comparison with shadier areas. Here, gleyed soil with oxidized root channels indicated that these areas are dry during some periods of the year, but have periods of inundation. The swale systems exhibit similar soil profiles to the wetland pockets. While many of the swales were dry, wetland plants were present in soils with organic content, indicating hydric conditions during part of the season.

Valley fill areas have retained some soil nutrients to maintain original forest cover in areas that were undisturbed. However, due to the steep topography and an oak-dominated vegetation profile, it is likely that the soil profile is shallow and less developed. Steep slopes typically cause soil to erode more easily, which is evidenced from the formation of gullies and sedimentation in the pond areas below. The terraced areas containing rock weirs are similar to the gravely silt loam soils in the fill areas. However, compaction is significantly less, which has caused some areas to be less stable. Sinkholes and settlement has occurred on several terraces that contain less gravel content. Erosion is evident along the edges of the stone weir channels. The most heavily eroded channels are in the southerly valley fill, adjacent to the residential neighborhood. Significant sedimentation in this area is evident. Valley fills are often susceptible to erosion as fill material is less compacted and stone weirs create point controlled hydrology. These valley fills are further stressed, due to their downstream location along the hydrologic chain on the mine- scarred land.

Failure of the rock highwalls is a concern. These walls are formed from siltstone, shale, fine grained sandstone and coal. During restoration, typically the site is graded to form gentle slopes that would not leave an exposed rock face. Since these rock highwalls are susceptible to erosion and sheer failure, an appropriate angle of repose should be considered during development. To ensure people's safety, it is recommended that no buildings are constructed within a distance of twice the height of the rock highwall.

On March 29, 2012, project researchers walked the site and collected eight soil samples in varying locations (Figures 36 and 37). Samples were collected in order to determine the type of soils and quantify their chemical composition. Soils were collected and tagged in laboratory-provided bags and sent to be analyzed at the West Virginia University Extension Services Laboratory in Welch, West Virginia for analysis. Results are shown in Table 11. All chemical constituents are in normal range for filled mine land.

Figure 36. Soil sample collection location A, Indian Ridge site, McDowell County, West Virginia.

Indicative of post-mining conditions, the soil horizons were generally less than one foot in depth before extensively rock-laden fill material was encountered. Researchers concluded that the site's dominant soil type consisted of an oxidized grey to black silt-loam with various intermittent rock fragments. Preliminary research concludes that the soil type will not be a limiting factor in the variety of biofuel grass that is planted and harvested for biofuels at the site in Welch, West Virginia.

Figure 37. Soil sample collection location B, Indian Ridge site, McDowell County, West Virginia.

Table 11. Results of surface soil samples collected at the Indian Ridge site, McDowell County, West Virginia.

				Lbs / acre				Meq / 100 g					% Saturation				
Sample ID	Sample Date	pH	L.R.	P	K	Ca	Mg	K	Ca	Mg	H	CEC (Total)	K	Ca	Mg	H	BS (K=Ca=Mg)
1	3/29/2012	4	7.9	2	62	330	284	0	1	1	16	18	1	5	7	89	13
2	3/29/2012	5	3.6	15	91	911	461	0	2	2	7	12	2	20	17	63	39
3	3/29/2012	4.8	3	35	164	905	342	0	2	1	6	10	3	23	15	61	41
4	3/29/2012	6.1	0.9	126	153	1587	509	0	4	2	2	8	3	50	27	23	79
5	3/29/2012	7.2	0	83	127	1662	598	0	4	2	0	7	3	62	37	0	101
6	3/29/2012	6	0.9	70	113	1382	490	0	3	2	2	7	2	47	28	25	77
7	3/29/2012	6.2	0.9	111	137	1406	512	0	4	2	2	8	3	47	28	24	78
8	3/29/2012	4.4	8.7	10	82	403	266	0	1	1	17	20	1	6	6	89	13

Hydrology

Site hydrology is heavily engineered, consisting of valley fills with channelized stone weirs, swales formed by berm shaping and concrete pipe networks that manage drainage associated with the construction of a Federal Correctional Institution (FCI) at the site. Hard engineering solutions using pipes and detention overflow structures are limited to the FCI-McDowell area. Hydrology can be best described in two sections, the FCI/southerly valley fill area and the northerly valley fill area. Construction of an access road north of the FCI has created a ridge hydrologically disconnecting these systems.

FCI and South Valley Fill

Stormwater along the site entrance to FCI-McDowell is managed through traditional roadside ditches consisting of turf lawn and check dams that slow water and limit sediment movement. Parking and other hardscape drainage is collected through a series of catch basins and concrete pipes. The swales and pipe systems are directed to three detention basins located on the northwesterly, southwesterly and southerly sides of the site.

While traditional swales and concrete pipes provide little ecological value, the stormwater basins are filled with a variety of native and invasive grasses that provide some water quality and habitat benefits. Unlike turf lawn swales and concrete pipes which move water quickly, the basins slow stormwater movement allowing sediment to fall out of suspension, while vegetation assimilates contaminates from the hardscaped area runoff. In addition to sediment control and nutrient assimilation, water temperature is also an indicator of water quality. Cooler water temperatures contain a greater amount of dissolved oxygen to support fish and aquatic vegetation. Concrete pipes and open water in basins and swales yield higher water temperatures. While grasses and forbs in the stormwater basins help mitigate higher water temperatures, the addition of shrubs and trees would create a canopy to shade and cool water. Shrubs and trees also help stabilize banks and reduce sediment movement to a greater extent than the existing forbs and grasses.

The stormwater basins outlet into valley fill areas. The northerly basin discharges into the utility corridor and the southerly basins discharge directly to a constructed valley fill. Both systems' hydrology are connected and flow to the adjacent residential valley. Stormwater from the site has resulted in an excess of sediment in the valley.

While the basins collect sediment from FCI McDowell, they discharge from a single outlet along steep, sparsely vegetated slopes, accumulating sediment along this path. Point source discharge along steep slopes force the water to channelize and move quickly through the valley fill, eroding the sides of the stone weir channels. The northerly basin further contributes to sediment movement as it discharges to bare soil along the unrestored utility corridor. Reducing stormwater contained within these ponds, vegetating the utility corridor and reconfiguring basin outlets to evenly redistribute water to multiple point sources that use a combination of stone and vegetation stabilization will help reduce sedimentation in the residential valley.

A constructed swale system, formed by berms, manages stormwater in undeveloped areas of the site. Swales run along the highwalls and surround many of the valley fill areas. The highwall swale system is generally narrow and shallow in depth. There are areas where the berm is less pronounced, allowing water to disperse and become less channelized. Here there is evidence of standing water and cattail vegetation. These areas yield some infiltration as water movement is slowed, however soil compaction has slowed this process. Enhancement of the swale and shallow ponding areas should be considered in restoration. This system of vegetative water movement and settling is common in low impact development practices.

North Valley Fill

Similar swale systems surround the valley fill areas. While the southerly valley fills generally have shallower swales similar to those along the highwalls, the northerly areas have very deep swales with high, steeply sloped berms on each side. These swales are dominated by cattail species (*Typha spp*) indicating hydrologic conditions. However, these swales do not appear to be hydrologically linked to the greater site. The berms create a barrier to stormwater movement. This fragmentation has created deep, linearly isolated wetland infiltration areas. Due to the excessive soil compaction and stormwater runoff isolation, these areas act similar to bog ecosystems, with rainfall being the only connection to hydrology. Sphagnum moss (*Sphagnum spp*), a common bog species, is present in several areas along these swales.

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There are two ponds in the northerly valley fill area. The ponds are separated by a berm that allows for a hydrologic connection when the water level rises high enough. It is possible that water infiltrates the berm as well, moving from the northerly pond to the southerly pond. The access road to the site that extends west of the FCI creates a ridge, disconnecting stormwater movement from this area to valley fills further downstream. Since the water is isolated with no outlet and erosion is present on the nonforested slopes, there is significant sedimentation in this pond system. This is evidenced from the lack of water clarity within the pond.

While, many of the swale systems provide an important stormwater service, the swales surrounding this valley fill region provide little functional value. They are unsightly and create a significant safety hazard. Regrading in this area to provide hydrology capacity and ensure the people's safety will be considered during the design. Solutions must consider the sedimentation problems in the valley fill ponds and ensure that no further sediment movement is directed here.

Researchers collected surface water samples from small flowing watercourses at the site (Figures 38 and 39) for the purpose of characterizing the composition of water in post-mine conditions. The water samples were sent to the National Research Center for Coal and Energy (NRCCE) laboratory in Morgantown, West Virginia and analyzed for pH, alkalinity, acidity, conductivity, sulfates, and heavy metals. Laboratory results indicate that the pH of surface waters at the site is near 6.50 and are net alkaline (Table 12). Alkalinity, pH and all other tested chemical parameters fall into the normal range and are indicative of typical surface water in valley fills located in southern West Virginia. Currently there are no groundwater monitor wells onsite.

Figure 38. Water sample collection location A, at Indian Ridge site, McDowell County, West Virginia; area view (left), and close-up view (right).

Figure 39. Water sample collection location B at Indian Ridge site, McDowell County, West Virginia; area view (left), and close-up view (right).

Table 12. Analytical results of surface water samples collected from the Indian Ridge site, McDowell County, West Virginia.

	pH*	**Alkalinity**	**Acidity**	**Cond.**	**Al**	**Ca**	**Fe**	**Mg**	**Mn**	**SO4**	**Na**
	150.1	SM2320B	SM2310B	SM2510B	200.7	200.7	200.7	200.7	200.7	375.4	200.7
	mg/L	mg/L	mg/L	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Date Sampled		**1**	**1**	**2.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.032**	**0.1**
03/29/12	6.49	101.46	<1	684	<0.1	94.7	<0.1	48.23	<0.1	259	12.2
03/29/12	6.53	61.55	<1	519	<0.1	54.9	<0.1	27	0.31	187	11.1
		Cl	**Br**	**K**	**As**	**Ba**	**Cd**	**Cr**	**Pb**	**Ag**	**Se**
		300	300	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		0.44	**0.088**	**0.1**	**0.047**	**0.012**	**0.014**	**0.012**	**0.032**	**0.045**	**0.045**
		1.46	<0.088	4.37	<0.047	0.071	<0.014	<0.012	0.053	<0.045	<0.045
		1.56	<0.088	2.38	<0.047	<0.012	<0.014	<0.012	0.037	<0.045	0.097

Vegetation

Upland forested areas surrounding the site are comprised of a mixture of hardwood species dominated by Alleghenny-Cumberland dry oak forest and hardwood species such as red, black and scarlet oaks (*Quercus rubra, Quercus velutina*, and *Quercus coccinea*). Also present are some Appalachian cove forest species such as red maples (*Acer rubrum*) and yellow poplar (*Liriodendron tulipifera*). The face of the highwalls is generally void of soil and vegetative cover, except in areas where water is penetrating the rock face. Willows (*Salix spp*), an indicator of hydrology, are growing along these water patterns.

Vegetation above the valley fill areas, contained within the highwalls can be described as successional pioneer species comprised mainly of grasses and forbs with some sparse native and invasive tree and shrub species. Dominate non-woody and highly aggressive vegetation such as birdfoot trefoil (*Lotus corniculatus*), broomsedge bluestem (*A. virginicus*) and crown vetch (*Securigera varia*) are an indication of acidic, low fertile soils. These plants grow in dry, shallow soil profiles and along rocky berms. Crown vetch (*S. varia*) extends throughout valley fill areas where trees are not present. While the invasive nature of crown vetch (*S. varia*) leaves little space for native vegetation establishment, other aggressive and non-native plants such as broomsedge bluestem (*A. virginicus*), Chinese mint (*Elsholtzia stauntonii*), and autumn-olive (*Elaeagnus umbellata*) have sparsely grown along valley fill terraces. Chinese mint (*E. stauntonii*) has aggressively spread beyond the valley fill areas.

Native species such as staghorn sumac (*Rhus typhina*) and highbush blackberry (*Rubus allegheniensis*) are growing along berms where a shallow soil profile is present. These species further indicate the presence of acidic soil conditions. While they suggest low soil fertility, they provide food and nesting cover for a variety of species. These shrubs exhibit an aggressive growth pattern, creating an extensive root network providing soil erosion control and bank stabilization.

Pioneer tree species such as black locust (*Robinia pseudoacacia*) and empress tree *(Paulownia tomentosa*) are present along berms. While black locust (*R. pseudoacacia*) species are found throughout the site, the empress tree (*P. tomentosa*) is mainly localized to the northerly valley fill region and areas that were disturbed during utility construction. Although there are many efforts in the region to eradicate the empress tree (*P. tomentosa*) because it is considered an invasive species, this tree along with the black locust (*R. pseudoacacia*) provide nitrogen benefits essential for soil development and plant nutrition. The leaves of the empress tree (*P. tomentosa*) provide nitrogen during decomposition and black locust trees (*R. pseudoacacia*) have the ability to fix nitrogen from the atmosphere in a form that is accessible for plant uptake. Black locusts (*R. pseudoacacia*) provide additional benefits through their symbiotic relationship with mycorrhiza fungi. This fungus is an important component of soil life and chemistry as they facilitate nitrogen and phosphorous aiding in plant uptake of soil minerals and nutrients. The black locust (*R. pseudoacacia*) and introduction of other legume species will be important for rehabilitating soils throughout the mine- scarred lands.

There are several areas throughout the site where wetland vegetation is present. Drainage swales surround the site highwall edge and interior valley fill regions. Sedge species (*Carex spp.*) and woolgrass (*Scirpus cyperinus*) populate narrower swales, where gentle slopes facilitate water movement. Drainage movement through the swale system is interrupted by flat areas where hydrology disperses and infiltrates slowly. These areas, along with several small isolated wetland pockets are dominated by narrow-leaved cattail (*Typha latifolia*) and hybrid cattail species (*Typha x glauca*). Although these cattail species are highly aggressive and considered invasive, they can perform an important function on mine reclamation sites. They are often planted for their ability to survive acid mine drainage (AMD) conditions, remove heavy metals from solution and provide

biomass and organic carbon that generate microbial alkalinity. It will be important to manage cattail aggression by considering native wetland plants that can thrive in acidic soil conditions and can compete and coexist with cattails (*Typha spp*). Since sedges (*Carex spp.*) and woolgrass (*S. cyperinus*) are successfully established within site hydrologic areas, these species along with several willow species (*Salix spp.*) should be considered when further developing site hydrology.

A similar species composition of red, black and scarlet oaks (*Q. rubra, Q. velutina, and Q. coccinea*), red maples (*A. rubrum*), and yellow poplars (*L. tulipifera*) in the upland forest is established along undisturbed valley fill slopes. This indicates that mine-scarred areas, though fragmented, are a continuation of the surrounding forest. These isolated patches should be linked to create wildlife corridors for species movement. As previously mentioned, crown vetch (*S.varia*) is the dominate plant along disturbed terraced valley fill regions, with broomsedge (*A.virginicus*) and autumn-olive (*E. umbellata*) beginning to colonize as well. The trifecta of these species make the establishment of native species difficult. However, as the area succeeds to a forested land cover, the adjacency of many native hardwoods may yield a healthier ecosystem.

GIS Analysis of Site Conditions

The maps below show overall site conditions in terms of elevation (Figure 42), land cover (Figure 43), and slope (Figure 44). A brief analysis detailing how the information assisted in making planning decisions is provided for each map. Elevation mapping allows researchers to understand the opportunities and constraints of the overall site for different types of development. Figure 42 demonstrates that much of the site contains areas of high elevation gradients that would create issues for different types of alternative energy facility implementation.

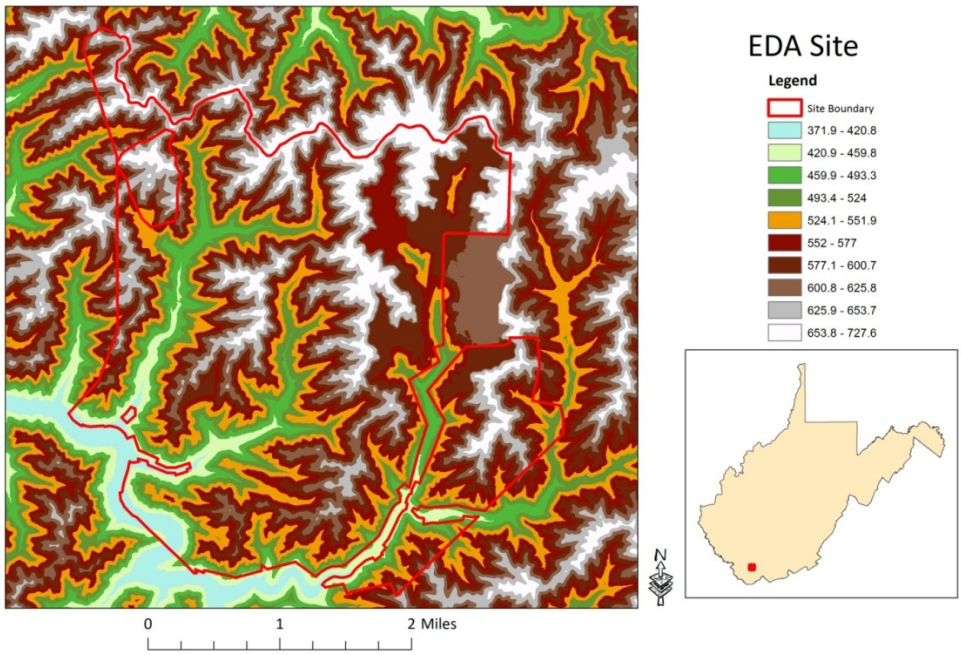


Figure 40. Overall elevation conditions at the proposed SEP site, Indian Ridge, McDowell County, West Virginia

The land cover map (Figure 43) illustrates that the overall site is primarily forested with some areas of previous disturbance due to a history of surface mining. Land cover data allows researchers to make informed decisions regarding future site programming and activities. In areas of existing forest a recreation program may be suitable. In areas of disturbance more industrial types of development would be more appropriate. The 'Forest in Permit' areas are currently being surface mined or may be mined in the near future. With foresight these areas may be reclaimed in such a way as to prepare them for future alternative energy facilities. The 'Mine Grass' area to the east of the site is the Indian Ridge Industrial Park site which includes FCI-McDowell (shown in black). Because of the existence of mine grass, which was confirmed through site visits, this area may be appropriate for biomass cultivation with soil amendments.

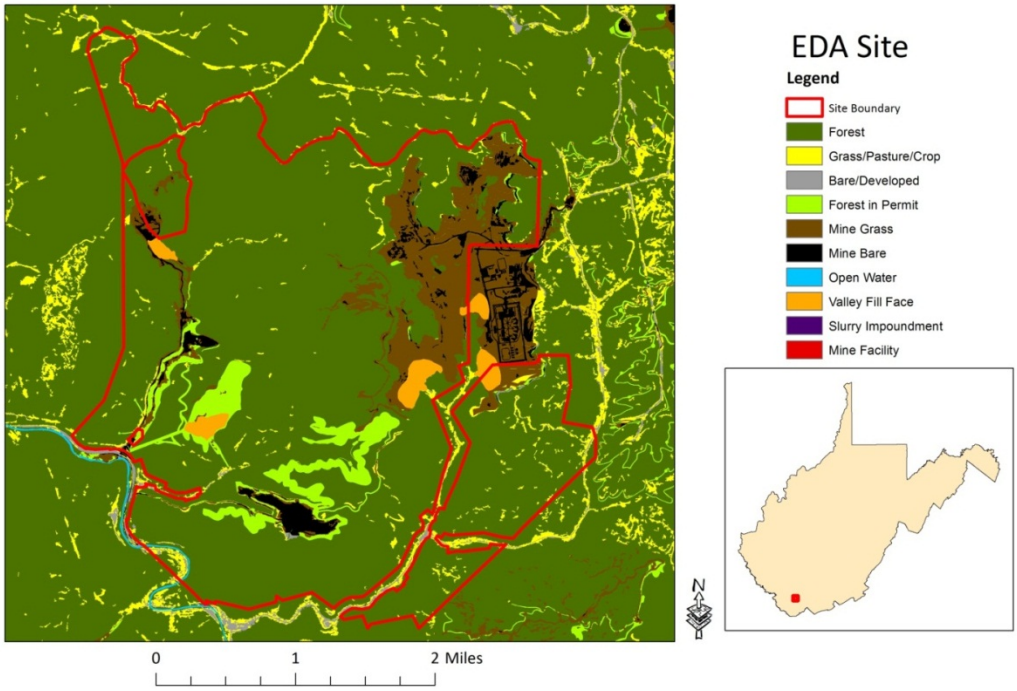


Figure 41. Land cover map of the proposed SEP site, Indian Ridge, McDowell County, West Virginia.

Figure 44 depicts slope in degrees, which provides very strong guidance in siting development within the project boundary. Desirable slopes for constructing buildings generally fall between 0-10 degrees. Biomass production would generally be restricted to areas with a slope of between 0-5 degrees. All of the green areas would be very difficult to build upon with the costs outweighing the benefits. The blue area, the Indian Ridge Industrial Park, is the most suitable area for mixed use development.

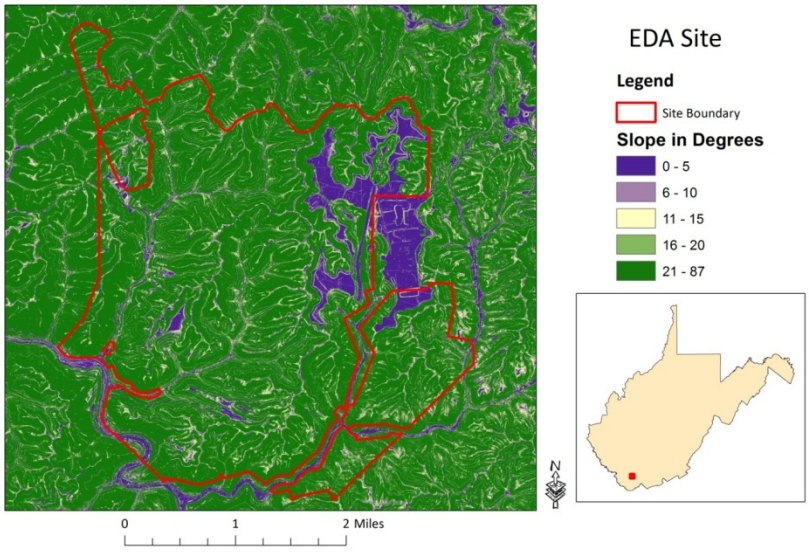


Figure 42. Slope in degrees at proposed SEP site, Indian Ridge, McDowell County, West Virginia.

Slope aspect tells researchers the direction (North, South, East, West) that the particular land surfaces are facing. Especially important for this project is the relation of the land surfaces to the cycles of the sun. Figure 45 indicates areas that would be most suitable for siting of solar panels within the design site. Other factors that would affect siting of solar infrastructure include slope gradient and soils because of the potential restrictions of steep slopes making installation of panels difficult, and soils because of the need for stable subgrade. Level areas within the Indian Ridge Industrial Park are also suitable without regard for slope aspect as these open areas would allow for full exposure to the sun.

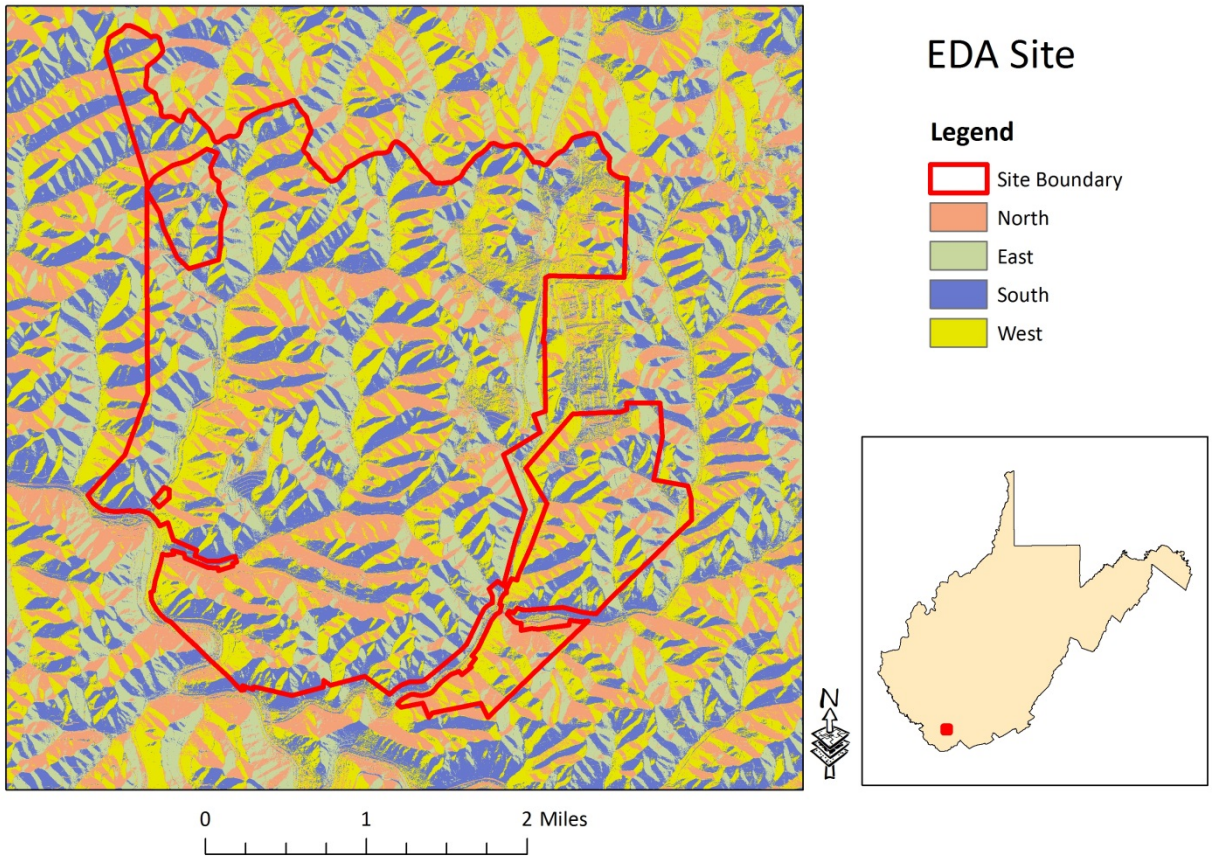


Figure 43. Slope aspect at the proposed SEP site, Indian Ridge, McDowell County, West Virginia.

Process for the Creation of Comprehensive Development Plan

Administer Participatory Planning Process with Officials and Experts

The participatory planning process with local officials began with the meeting in Welch, West Virginia, in March, 2012. Alternative energy experts were engaged to provide practical critique of project design when conceptual designs are completed. Researchers met with West Virginia regional solar energy experts (MTV Solar) to discuss collaboration/review of solar infrastructure design. Researchers met with US Windforce to discuss wind infrastructure design. These two industry representatives, as experts in their respective fields, provided significant critiques as the design of the site evolved.

Local Official Participation

Researchers administered a meeting to discuss the SEPs project in Welch, McDowell County West Virginia through the Economic Development Authority. The meeting allowed researchers to learn local concerns and opportunities related to the industrial park at the Indian Ridge site. Stakeholders at the meeting identified groups and individuals for engagement in the participatory planning process. There were multiple purposes identified for the meeting: To introduce WVU team members and McDowell County Officials and attendees; to introduce the SEPs Project to local McDowell County Officials and other attendees; to discuss potential stakeholder groups for participation in planning process; to discuss a potential public-wide engagement strategy during project planning; to discuss other opportunities that may be addressed during the planning process, ie. industrial park location and design; opportunities created by expressway alignments; public recreation needs; Gateway opportunities; National Coal Heritage Trail (NCHT) connections; etc.; to clarify SEP site boundary; and to coordinate a visit to the project site for surveying purposes (LiDAR and environmental assessment). The meeting occurred on Wednesday March 28, 2012 and site visits followed that afternoon and the next day.

The meeting brought local insights and sensitivities to the research team. One of the key outcomes of the meeting was to identify other groups for participation. The identified groups included: The local Chamber of Commerce, local schools, Southern West Virginia Community College (Saulsville), WVU Extension, 4-H, Copper Ridge Landfill, and FCI-McDowell. Individuals involved in alternative energy projects currently active in McDowell County were also identified including high school teachers who work locally with the Health Sciences and Technology Academy (HSTA). Local alternative energy projects include a solar experiment at Mount View High School; and potential methane harvesting at Copper Ridge Landfill.

Local knowledge communicated during the meeting assisted researchers in defining the boundary of the site for planning. Individuals at the meeting had worked closely in bringing FCI-McDowell to the property; the group had gone through several iterations of planning and design in envisioning future use of the industrial park. The site had been identified for mixed-use development through a land use master plan developed for the West Virginia Division of Energy and Office of Coalfields Community Development. The mixed-use development for the site is appropriate as it is the location of the future interchange between the King Coal Expressway and the Coalfields Expressway. The participants had identified 'new' energy development opportunities for the site including a possible Hydro-Pump project and a possible Mine-Water-Heat energy generating facility. The group perceived a relationship with FCI-McDowell to be a strong opportunity for partnership through work camps and green energy job training programs.

In terms of recreation, participants had witnessed the positive economic impacts of the regional all-terrain vehicle trail and envisioned potential connections to the Hatfield-McCoy trail, specifically reaching out to Ashland, West Virginia where trail alignments had been defined. The participants did perceive a potential conflict in developing a 'formal' trail system in McDowell County. Specifically they thought that residents may resist paying the fees and following the rules if trails were proposed for the project site. Participants discussed the potential for specific county resident access without major restrictions.

Another connection that would benefit site development was with the NCHT - US Route 16. As a gateway from the planned expressways (King Coal and Coalfields Expressways) to the historic and cultural resources of the established route, the industrial park site would be a key hub in drawing visitors to the region.

Participants also identified key community needs in real estate and economic development. Through local discussions the group identified a need for rental properties. Many of the workers at FCI-McDowell commute over an hour to work. Local housing does not satisfy the demand. They also see a need for a hotel/motel at the industrial park site. Visitors to the FCI have difficulty finding overnight lodging.

Assets that participants identified through discussion included existing site infrastructure. Existing infrastructure includes roads, water, electricity, and other utilities. Water retention for runoff was established in the mine reclamation process. Discussants also perceived strong potential in providing utility support for the FCI.

Expert Participation and Consultation

As a planning component of the project, regional experts in the field of alternative energy generation were consulted multiple times throughout the project development. Solar energy experts (MTV Solar) were recruited to discuss collaboration and in their role as potential reviewers of solar infrastructure design for the McDowell site. Their participation allowed for the most context-sensitive design solutions as they work to design, implement and manage solar infrastructure projects throughout the northeastern region. As a company they are committed to building local economies through alternative energy projects, training local contractors and educating the public. Their participation may have positive impacts on the residents of Welch and the region.

Wind energy expert consultation consisted of meeting with US Windforce, a key player in developing wind energy projects at the Allegheny Front, particularly in Logan County, West Virginia. They portrayed very clearly the financial margins necessary for completing a privately funded project. Their input provided insight into the feasibility of the McDowell County project. When design and planning is more fully developed for the site, US Windforce's participation will be a key component to grounding the planning project within the realities of wind energy development on the site.

Focus Group Meetings

Following the meeting with officials at the McDowell County Economic Development Authority, focus group meetings were organized. To gather a broad base of input, three focus group meetings were scheduled, in addition to meetings with newly identified stakeholders. The meetings were held on June 14, 2012 at the Welch Public Library. After the meeting with McDowell County EDA, leaders of the Copper Ridge Landfill and administrators at FCI-McDowell were contacted for private meetings. Focus groups were organized under the subject areas: Education, business/industry, and recreation. With the input of the EDA already establishing a mixed use program, researchers decided on more specific and detailed topical areas for coverage in focus group meetings. Questions designed to spur conversation between participants were consistent across the three groups though with different areas of emphasis. Individuals were contacted for participation through e-mail and telephone calls. Many were eager to contribute their input to the project. The following discussion lists the questions asked of each focus group, followed by the results of each focus group. The concluding section translates collected information to planning and visualization of the master plan and potential project and program initiatives.

Participation with Local Youth

In order to address questions and concerns of local youth an event was scheduled at the McDowell and Wyoming County 4-H Camp with a self-selected student group. In this way the group would be small enough to engage in a meaningful way. An agenda was set for the meetings with 4-H students that sought to educate them on the project and provide a forum for discussion. It was also hoped that the students would contribute meaningfully to the design process. The 4-H Camp was held in Glen Fork, WV during the week June 25-29, 2012 (Figure 46). Working with a youth group was a very important component of the project in that their contributions gave voice to an underserved

population group, and it is hoped that as the next generation of adults they may recognize potential 'new' energy opportunities as defining their region, especially as a viable reuse strategy for surface mined sites.

Figure 44. Working at the 4-H Camp at Glen Fork in Wyoming County, West Virginia with students from Wyoming and McDowell County High Schools.

Business Planning for Sustainable Energy Park Development

Determining the feasibility of alternative energy development on surface mined lands in West Virginia has been completed through an analysis of market and economic factors for biomass, solar, and wind. Each energy type is reviewed as an independent opportunity to provide investors with a background on the potential to develop each energy type as part of a SEP. The final decision on which energy types are a part of the SEP will be largely driven by the economic conditions and access to markets, as well as the local support and incentives for the development of a particular energy type. A market and economic analysis of biomass, wind, and solar markets is provided below to assist in evaluating SEPs for business planning and development purposes.

Market and Economic Analysis for Biomass

Identifying and understanding potential markets for switchgrass produced on surface-mined lands in West Virginia includes a literature review focusing on production cost estimates, identification of relevant facilities in the region, and a series of interviews with industry participants. A full report on market opportunities for switchgrass in Appalachia is provided in Appendix L.

There are three opportunities to use switchgrass in energy conversion systems: 1) co-firing with coal in power plants, 2) as the feedstock for cellulosic ethanol production, and 3) as a material for stove pellets. None of these potential markets are presently developed, although substantial efforts have been made to establish co-firing.

In terms of potential volume the best regional market opportunity is in co-firing with coal in power plants. American Electric Power (AEP)-Ohio is currently capable of utilizing up to ten % biomass in several coal-fired power plants. Through this research it has been made clear that in spite of a large request for proposal issued by AEP in 2010 there are presently no stable markets for switchgrass in the region. Some of the reason for a lack of market is due to the physical properties of switchgrass and some is due to its uncompetitive production costs. The cost of producing switchgrass is a large

barrier to taking advantage of this potential market. Material handling is an additional barrier to widespread use that has been partially addressed by the industry.

In the electricity market, biomass must compete with wind power because renewable portfolio standards do not contain a biomass mandate. Although both wind and closed-loop biomass receive the same production tax credit of $22/MWh, wind is a resource with extremely low operating costs. Utilities must still seek the energy that can be procured at the lowest cost to their customers or risk being unable to fully recover costs.

Emerging Market Opportunities for Switchgrass

Biomass co-firing: In February 2010, AEP has implemented co-firing tests with grass pellets and pellets pre-blended with coal. Pre-blended pellets have emerged as the preferred fuel but the cost of the fuel to date has prevented AEP from considering long-term use at this time or entering into a term deal with a biomass supplier. Table 13 summarizes AEP's stated plant-level biomass capabilities.

Table 13. AEP biomass supply specifications by plant (as of February 2010).

Plant	Megawatt Capacity	Maximum Chip Mesh Screen Size	Maximum Pellet Size (Inches)	Maximum Biomass Blend (%)	Acceptable Transportation
Picway	100 MW	3	2 in.	10%	Truck
Muskingum 1,2,5	1425 MW	6	2 in.	4%	Truck, Rail
Muskingum 3,4	Included with plants 1,2,5	4	2 in.	10%	Truck, Rail
Conesville	1300 MW	6	2 in.	4%	Truck, Rail
Gavin	2600 MW	6	2 in.	4%	Barge
Cardinal	600 MW	6	2 in.	4%	Barge, Truck, Rail

Data Taken From AEP Biomass Coal Blend RFP (American Electric Power, 2010)

AEP has stated that they need to obtain biomass within the price range of $6.50 to $7/mmbtu to be competitive with purchasing renewable energy credits in the market. The utility also stated that long-term prices proposed to them have been in the range of $8 to $10/mmbtu for biomass (Banner, 2010).

Cellulosic Ethanol production: Nationwide there is little production of ethanol from switchgrass or from any intentional energy crop. The closest production location is a 250,000 gallon pilot-scale facility in Vonore, Tennessee. That plant is in the process of converting its feedstock from corn stover to switchgrass as soon as it stabilizes the enzymatic process. Unfortunately, the distance to the Knoxville area will prevent any West Virginia producers from supplying that facility, as plant managers indicate they have ample access to switchgrass within 50 miles of the site.

A cellulosic ethanol-capable facility in Madison, Pennsylvania is presently using wood chips as its feedstock. That facility uses a fuel-flexible gasification process and is capable of using switchgrass. The plant is a research and testing facility run by Westinghouse Plasma Corporation. It is not a dedicated ethanol producer. Both feedstock and product (electricity, steam or ethanol) are used and produced according to customer request.

Stove Pellets: Stove pellets made from grass have not been marketed in the area, but there is an established market for wood pellets. Demand for pellet stoves jumped in 2008, with some growth

likely attributed to a federal tax credit for such purchases and some due to high natural gas and petroleum prices. Whether these stoves are capable of burning grass pellets as effectively or desirably as wood is uncertain, although some types of stoves are capable of burning multiple fuels.

Regional wood pellet manufacturers are presently not seeking alternative materials to use in production and do not appear interested in switchgrass.

Wood pellet manufacturers in the area:
Hamer Pellet Fuel (based out of Kenova, West Virginia)

- Facility in Elkins, West Virginia
- Facility in Mount Hope, West Virginia
- Both plants manufacture a premium grade pellet made from hardwood sawdust

Lignetics

- Located in Glenville, West Virginia

Wood pellet retailers in the area:

- Lowes - Currently carry wood pellets and wood stoves
- Home Depot - No longer carries wood pellets or stoves, but carried the products last year
- Kenny Queen Hardware
    - Lavalette, West Virginia
    - Carries wood pellets and stoves
- Other miscellaneous hardware stores throughout the state

Costs of Production

The costs of growing and transporting switchgrass apply to any of the three potential markets. The cost of delivering a ton of switchgrass is used here as a proxy for the price a producer would have to receive to break even.

Oak Ridge National Laboratory (ORNL) manages a large switchgrass growing operation in Tennessee, the volume of which will be used in a cellulosic ethanol pilot refinery. Given the lab's extensive history with switchgrass production their cost estimates are among the best available. Using figures compiled and published by ORNL (Oak Ridge National Laboratory, 2009) the cost of switchgrass production is summarized below in Table 14.

Table 14. Switchgrass production costs.

Variable costs (Fertilizer) – Nitrogen, Phosphorus, Potassium and Lime = $78.74/acre. With interest on variables costs = $81.10/acre.	$81.10/acre
Harvest Costs - Harvest costs are the sum of the mowing and conditioning plus the combined operations of pickup and transport to the field edge. These costs include the fixed costs of equipment: tractor, mower-conditioner, forage harvester, windrow pickup head and high dump forage wagon. It incorporates hourly rates for specific equipment plus acreage covered per hour.	$65.32/acre
Overhead - Overhead includes such items as: office expense; fuel, lube, and utilities (not previously included in the machinery cost estimates); maintenance and repairs on buildings; machinery and equipment (not previously included in the machinery cost estimates); and farm insurance (not previously included in the machinery cost estimates). ORNL uses the average of that published by the American Agricultural Economics Association (AAEA) for corn, soybeans and alfalfa.	$13/acre
Land Rent – Using the state average for pastureland rather than for cropland.	$12/acre
Total Production Costs: The study assumes a yield of 4.02 dry tons/acre, which	$34.28/ton

places the total in-field production costs at $45.91/dry ton. With a yield of five tons/acre, and using average pastureland rents, the cost improves.	with better yield
Storage costs are based on outside storage on a prepared gravel surface with a reusable tarp for cover. These are assumed to apply to the entire tonnage produced and include expected dry matter loss of about 6%.	$12.86/ton
Transportation costs depend on distance to a pelletizing facility, represented by hours of use for a single flatbed tractor trailer. Estimated costs incorporate truck purchase cost, diesel fuel, labor and variable mileage costs and are based on a range of miles traveled of between 45,000 ($80/hr) and 150,000 ($65/hr) per year. This equates to a range of costs between $120,000 and $325,000 per year.	$118,519 per year
Estimated Total Production and Transport Costs – For switchgrass production of 10,000 tons per year on a 2,000 acre plot.	$589,919
Total Costs/Break Even Price per Ton – Given the assumptions above, this is the price a facility would have to receive from a densification facility to break even.	$59/ton

Compiled from data from (Oak Ridge National Laboratory, 2009)

Regional Facility Summary

The following facilities are involved in one of the three markets (Co-Firing, Cellulosic Ethanol Production, Stove Pellets). As of the date of this report, none of these facilities are viable partners because of distance, lack of interest in switchgrass or inability to support the cost of delivered switchgrass pellets. Due to the fluidity of the fuel costs, and current economic conditions, the facilities should be contacted prior to ruling them out as a viable partner for future endeavors.

- DuPont Danisco/ORNL cellulosic ethanol facility in Oak Ridge, Tennessee area.
- Wood pelletizing facilities (Kenova, West Virginia)
- American Electric Power coal-fired power plants that can accept switchgrass pellets, preferably pre-blended with coal.
    - Cardinal Power Plant (Brilliant, Ohio)
    - Gen. James M. Gavin Power Plant (Cheshire, Ohio)
    - Conesville Power Plant (Conesville , Ohio)
    - Muskingum River Power Plant (Beverly, Ohio)
    - Picway Power Plant (Lockbourne, Ohio).
- Switchgrass pelletizing facilities - South Shore, Kentucky.
- Planned pelletizing facility - Catlettsburg, Kentucky.

A comprehensive report (Appendix L) describes the biomass industry, examines the current market for cellulosic biofuels, pellet fuels and co-firing with coal for electricity production to identify demand for switchgrass as a feedstock. Potential markets, competition within the market, and potential barriers are addressed. Costs and benefits, including indirect community benefits, nutrient capture from runoff, conservation, and CO_2 sequestration are included.

Federal Incentives

Researchers gathered information on the Biomass Crop Assistance Program (BCAP) that provides producers dollar for dollar match for the collection, harvest, storage, and transportation of eligible biomass to designated biomass conversion facilities. BCAP provides financial assistance to producers or entities that deliver eligible biomass material to designated biomass conversion facilities for use as heat, power, bio-based products or biofuels. Initial assistance will be for the collection, harvest, storage and transportation costs associated with the delivery of eligible materials. Rulemaking is to move forward in the near future to fully implement BCAP.

Market and Economic Analysis for Solar Industry

This task defines and quantifies the regional markets for solar and wind energy and provides information regarding which market is the best fit for energy produced from the energy park. Work under this task focused on developing an understanding of the primary drivers for purchasing solar energy in the region and the availability of financial incentives.

Overview of the Solar Power Industry

Production and installation of solar electricity systems of various sizes and capacities has grown sharply in recent years and continues to grow. There are approximately 40,000 MW of photovoltaic (PV) capacity installed worldwide, with about 2,500 MW deployed in the United States (Cory, Coggeshall, Coughlin, & Kreycik, 2009). In 2010, annual global PV module shipments exceeded 17,000 MW, a 120% increase over 2009, although going forward, research suggests that the growth rate could subside to a forecasted 14% growth in 2011 and 20% in 2012 (Electric Power Research Institute, 2011). Much of this recent growth was driven by stable federal incentives, largely tax credits and cash grants provided through stimulus funding which were concentrated in the year 2010 (IREC, 2011).

Demand and Supply Trends

Demand for solar energy systems in the United States is concentrated in the West, with California being the largest market with 28% of installed capacity in 2010 (Interstate Renewable Energy Council, 2011). The country experienced tremendous growth in demand in 2010 for both small-scale and larger, utility-scale installations due to both stimulus funding and state renewable portfolio standards in states with a solar mandate and an alternative compliance payment in place. The installed capacity of solar doubled between 2008 and 2010, with grid-connected systems now dominating current deployment (National Renewable Energy Laboratory, 2011a). As recently as 2007 the number of off-grid systems was greater than the number of on-grid systems.

Most solar PV installations are residential. As of 2010, more than 139,000 of 154,000 PV installations connected to the grid were residential (Interstate Renewable Energy Council, 2011). Utility-scale solar systems have also been installed in greater numbers in recent years and dwarf residential and average non-residential systems in size. Most of the 74 utility-scale systems - as listed in a PV Insider report - are located in the southwest and Florida, but 17 are located in the Eastern U.S. Additional projects are in the development stage.

Other industry trends include the increasing size of a solar system both for residential and non-residential installations. For residential installations the average system size increased from around 3 kW in 2001 to nearly 6 kW in 2010. The average non-residential system increased from around 30 kW in 2001 to 80 kW in 2010 (Interstate Renewable Energy Council, 2011). The amount of electricity generated by solar, tide and wave resources doubled during this time period (U.S. Energy Information Administration, 2011).

Pricing Trends

The price of solar PV modules has declined steadily over the last 30 years, falling to nearly $2 per watt in 2010 from $23 per watt in 1980 (NREL, 2011d). The cost of installed systems has fallen from about $11 per watt in 2001 to around $7 per watt in 2010 for “behind-the-meter” or utility customer-connected systems (NREL, 2011d). Larger systems, such as those evaluated in this report, are considerably less expensive per unit than residential and small commercial systems due to economies of scale and volume discounts. Systems sized between 500 and 750 kW cost $5.4 per watt on average, while systems larger than one MW cost $5.2 per watt on average (NREL, 2011c). Because of these economies of scale, larger solar facilities, such as those installed for or by utilities, have lower costs of electricity production compared to smaller systems.

Technology has also increased the efficiency of solar panels somewhat. Demonstrated cell efficiency for all types of solar modules has increased over the years, but commercially available modules typically do not reach more than 14% efficiency for crystalline systems and 11% efficient for thin film systems (NREL, 2011d).

The supply of solar panels manufactured in Asia has been one driver of reduced systems costs for consumers in the U.S. In 2010, 59% of all PV cells were produced in China and Taiwan (NREL, 2011b). In 2011, low-priced panels induced a "dumping war" of solar manufacturing products between the United States and China when the United States Department of Commerce stated that it was considering countervailing import duties against Chinese PV module producers, a move that benefited manufacturers in Taiwan (PVTech, 2012). According to the Solar Energy Industries Association (SEIA), U.S. solar PV manufacturers produced 1,100 MW of panels in 2010, nearly double that of 2009 (NREL, 2011c).

Types of Systems

There are several ways to convert solar energy into active useful energy, with the primary method used to produce electricity from moderate and low-grade solar resources being systems of photovoltaic (PV) cells. Passive solar energy also provides heating and lighting uses, but only active energy – conversion into electricity or high-temperature thermal energy – is discussed here.

There are three primary types of solar panels: monocrystalline, the less efficient polycrystalline and the even less efficient thin film or second-generation PV (NREL, 2011d). Thin film panels have no crystalline structure and can be applied as a film directly on various materials (Power-Talk.net, 2010). Semiconductor materials such as copper indium diselenide and cadmium telluride (CdTe) are connected to the same metal conductor strips used in crystalline cells but are less fragile and thus have lower manufacturing costs and can be produced more quickly. Crystalline wafers are about 200 microns, whereas thin film panels are made by vacuum depositing several layers of semi-conductor materials only a few microns thick. Silicon in its pure form makes up about 50% of the cost of crystalline panels relative to the semiconductor cost of about two % in thin film panels, making manufacturing costs for thin film cells considerably less than those of crystalline cells (Solar Cell Central, 2010). In addition, because they can be applied in thin layers to different materials they can be made flexible (Power-Talk.net, 2010). Thin film panels are the least efficient type of solar panel currently available, a factor that must be considered in exchange for lower costs. CdTe thin film cells accounted for about six % of cell production in 2010 (Solar Cell Central, 2010).

Other types of solar electricity systems include concentrator photovoltaic systems (CPV) and concentrated solar power (CSP) systems. CPV systems are highly efficient (40 %) and operate best in areas of concentrated sunlight. The goal of such systems is to provide high energy yield at low cost for the high solar resource regions of the world (SolFocus, 2012). CSP or "focused sunlight" uses mirrors or lenses to concentrate a large area of sunlight onto a smaller area of panels (for collection). This type of system of solar panels is widely commercial and contains three different techniques: trough systems, power trough systems, and dish engine systems (Argonne National Laboratory, 2011).

PV systems are most applicable to solar insolation found in geographies like West Virginia. For this analysis, a thin film system is assessed as it may have the lowest cost, although recent reports state that average installed costs were nearly identical for crystalline and thin-film systems larger than 100 kW (Lawrence Berkeley National Laboratory, 2011).

Solar Incentives
There are several types of financial incentives available for purchasing solar systems at the state and federal levels. These include tax credits, grants, loan programs and solar renewable energy credits (SRECs) tied to solar mandates within renewable portfolio standards.

Federal Incentives
The Energy Policy Act of 2005 (EPAct) increased federal incentives for solar energy for nonresidential installations and extended the investment tax credit (ITC) to residential installations. The ITC cap was removed by the Emergency Economic Stabilization Act of 2008 and the ITC extended 2016. This same act also made utilities eligible for the credit (Cory, Coggeshall, Coughlin, & Kreycik, 2009). This federal incentive allows individuals and corporations, including utilities, to receive an uncapped tax credit equal to 30% of the cost of the PV system. This incentive is set to expire at the end of 2016.

The American Recovery and Reinvestment Act (ARRA) initially allocated funds for solar energy projects placed in service or under construction by 2009 or 2010 although the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 extended the program for projects under construction by December 31, 2011 (Database of State Incentives for Renewables and Efficiency, 2012). Currently, tax-paying corporate entities are eligible to apply for a grant until October 1, 2012 (NREL, 2011c).

The Modified Accelerated Cost Recovery System (MACRS) allows investors to depreciate certain investments in solar power on their federal tax return using a 5-year accelerated depreciation schedule. This allows solar equipment to qualify for 5-year, double-declining-balance depreciation.

The stimulus-provided cash grant program was a stronger incentive for solar installations than the existing federal tax credit (IREC, 2011).

State Incentives
West Virginia does not presently provide any grants, however it does offer a tax credit for 30% (up to $2,000) of residential installation cost for solar PV and hot water (Database of State Incentives for Renewables and Efficiency, 2012). This incentive does not currently apply to commercial installations so it is not applicable to this project.

The State of West Virginia does allow solar PV projects to be net metered.

Solar renewable energy credits
Solar renewable energy credits (SRECs) have come to play a very important role in the demand for and utilization of solar energy. SRECs are state-specific markets for electricity generated by solar energy and are tied to state mandates that solar energy comprise a portion of renewable portfolio standards. Typically, one SREC is issued for each MWh of electricity generated from a solar electric system. The price of an SREC is tied to the rate required to be paid for non-compliance, a solar alternative compliance payment (SACP), and the existence of a SACP. Another important factor is whether the state SREC market is open or closed to systems installed outside of the state.

Regional states with SREC markets are New Jersey, Pennsylvania, Delaware, the District of Columbia, Maryland and Ohio. The State of North Carolina has a solar mandate but has no alternative compliance payment requirement and thus has no real market for SRECs, and only out-of-state systems registered prior to January 31, 2011, can continue to sell SRECs in the Washington, DC market (Table 15). Most of these states are closed to participation by outside systems. Ohio allows participation by bordering states only at an amount equal to 50% of the solar set-aside. Pennsylvania

is the only state whose SREC market is currently open to all states within the PJM Regional Transmission Organization region (Flett, 2012).

It has been stated that, in the case of Pennsylvania, market inclusiveness combined with lack of a firm SACP level has caused an oversupply of SRECs and suppressed prices. The Pennsylvania SACP is 200% of the average market value of SRECs sold in that energy year and is not disclosed until six months after the close of the energy year (Flett, 2012). New Jersey, on the other hand, has pre-set prices for SACPs. State legislatures are responsible for setting SACPs and some states adjust portfolio goals in an effort to keep prices high and avoid volatility, a role that some would argue is inappropriate for a governing body.

Table 15. Range of prices for regional SREC markets ($/MWh).

STATE	2012/2013 Compliant?	2012	2011	2010	Market Open To
Delaware	Yes/No	$40-$60	$60 - $260	$200 - $300	Delaware only
Washington, DC	No/No	$240-300	$20 - $325	$250 - $405	District of Columbia only
Maryland	No/No	$170- $218	$175 - $320	$320 - $390	Maryland only
New Jersey	Yes/Yes	$155- $245	$550 - $670	$640 - $660	New Jersey only
Ohio	Yes/Yes	$30 - $285	$30 - $400	$290 - $400	Indiana, Michigan, Ohio, Pennsylvania and, West Virginia
Pennsylvania	Yes/Yes	$16 - $20	$10 - $250	$200 - $310	District of Columbia, Delaware, Illinois, Maryland, North Carolina, New Jersey, Ohio, Pennsylvania, Virginia, West Virginia

Sources: (SRECTrade, 2011) and (Flett, 2012).

These prices in Table 15 show that the only potential markets that a solar PV system in West Virginia may be able to sell into are Ohio and Pennsylvania and that prices that can be expected to be received with certainty may be no more than $16 per MWh, or 1.6 cents per kWh, and could possibly be lower. As of May 2012, state solar portfolio requirements for 2013 are also already exceeded for both Ohio and Pennsylvania. SACP levels also decline over time and thus the value of new credits can be expected to decline each year. This greatly reduces the opportunity for a third party to profitably invest in a solar facility in West Virginia, Ohio or Pennsylvania. Financials that are based on receiving an SREC payment of $200 to $250 per MWh (20 to 25 cents per kWh) are potentially overestimating potential revenues by a factor of three, depending on the rate that the system owner would get from its utility net-metering arrangement.

Utilities generally do not purchase SRECs in contracts longer than three years. Small solar facilities, such as those on homes and smaller commercial installations may be able to get longer contract through intermediate parties that then resell the credits, but large facilities carry more risk when in long-term arrangements (SRECTrade, 2011).

Regional Markets for Solar Electricity

In the Eastern U.S., the market for solar electricity is driven largely by state portfolio standards and federal and state tax credits and other financial incentives. Markets for SRECs have made installing

solar systems affordable for many homes and businesses in the region. SRECs are supported through utility mandates and these costs are passed on to electricity customers in those districts. However, in most states Renewable Portfolio Standards requirements are primarily met with wind, legacy hydropower, and landfill gas generation (Kubert & Sinclair, 2010).

The supply of electricity in the region is highly interconnected. Reliability is ensured by a large number of utilities and coordinated by the PJM Interconnection, which operates wholesale electricity markets for the large majority of the electric grid in the immediate 11-state region. Because of this interconnectedness, and the fact that most states are not net generators of electricity, demand for and supply of electricity is regional. Demand for solar-powered electricity is somewhat less regional due to the closed status of many state-level SREC markets.

The inclusion of large solar PV systems in the grid is relatively new, but these units are treated like any other grid-connected generator. However, because solar energy is a variable resource it does receive special scrutiny by the system operator to ensure that it does not create over-supply of electricity or compromise the availability of operating reserves. PJM pays special attention to dispatch protocol for variable generation, such as wind and solar, to ensure fairness to those generators as well as to ensure system reliability. For example, PJM allows utility-scale wind and solar facilities to submit generation bids at negative prices in the wholesale market to distinguish themselves from other generators on the system.

Non-utility electric generators, such as the McDowell system under evaluation would likely be, are guaranteed access to the transmission system of the local utility at long as that interconnection does not overload the capacity of the line. This access is granted via the Federal Energy Regulatory Commission's (FERC's) Open Access Transmission Tariff (OATT) legislation, which has the goal to "remove impediments to competition in the wholesale bulk power marketplace and to bring more efficient, lower cost power to the Nation's electricity consumers" (Federal Energy Regulatory Commission, 2010). While the wholesale electricity market would not be lucrative enough to justify investment in the solar array, the system could purchase access to transmission and thus be able to "deliver" electricity to a customer in another state with whom it had a power purchase agreement (PPA). A facility like this that is not a net-metering customer would have to apply for interconnection with the local utility and the PJM Interconnection, whereas a net-metering customer could by-pass PJM as long as it did not plan to participate in the PJM marketplace (Public Service Commission of West Virginia, 2010).

Solar Financing

The ability to obtain financing to purchase a solar PV system depends on the future income stream from the facility. In West Virginia, net metering law allows a commercial facility to sell up to 500 kW of power back to the utility (Public Service Commission of West Virginia, 2010). Thus, for this type of arrangement the income stream from the facility is the commercial rate for a kWh of electricity multiplied by the output of the solar array. The existence of a net metering law can assist with the ability to get the funds to purchase the capital equipment.

Federal and state incentives have been an important part of financing solar because they reduce the upfront cost of the system and the amount of money that must be financed. Because many incentives are tied to tax credits only tax-paying entities can take advantage of the credits. Innovative financing methods such as New Markets Tax Credits can allow public entities without a tax liability to take advantage of such incentives by partnering with a private firm with a tax liability.

The use of a purchase power agreement (PPA) has been a growing way to finance projects. A PPA is an agreement from a utility or a qualifying non-utility electricity consumer to purchase the output of the facility at a specific rate. The existence of such an agreement allows the project developer to

acquire capital to build the facility. In 2007, an estimated 50% of installed capacity was developed under PPA agreements, up from 10 % in 2006, with the share projected to grow to 65-75 % of the market.

Federal Demand for Renewable Electricity

The United States federal government is the largest single energy consumer in the nation, accounting for about 1.5 % of primary energy consumption in recent years (Cory, et al., 2009). The Energy Policy Act of 2005 mandates that federal agencies use renewably-generated electricity in amounts not less than 7.5% in fiscal year 2013 and each fiscal year thereafter (Cory, et al., 2009). This mandate includes double credit for every kWh generated onsite.

The U.S. Department of Energy has produced a guide for Federal agencies called "Procuring Solar Energy" that provides information on planning for agencies interested in purchasing or installing solar systems (USDOE/Energy Efficiency & Renewable Energy, 2010). There are various options for structuring the financing of PV on federal facilities and land including the Energy Saving Performance Contract (ESPC), Super ESPC, Utility Energy Services Contract (UESC), and the third-party PPA ownership model (Cory et al., 2009).

A UESC is an alternative to a direct federal purchase. Under a UESC the local utility provides the agency with comprehensive energy efficiency and demand-reduction services, which can include solar installation. As Appalachian Power Company has a commercial energy efficiency program in place this alternative may be worth exploring. Under this model Appalachian Power would own and operate the system and thus be able to take advantage of the tax benefits (U.S. Department of Energy, 2011b). Under this structure, when PV is bundled with energy efficiency activities, federal energy intensity reduction mandates can also be furthered, which improves cost effectiveness (Cory et al., 2009).

There are many elements of a system that would need to be considered and the cost of a PV system combined with the relatively low insolation received in West Virginia may not produce a viable project.

Market and Economic Analysis for Wind Energy

Market Analysis for Wind Industry

This task defines and quantifies the regional market for wind energy and provides information regarding which market is the best fit for energy produced from a SEP. Work under this task focused on developing an understanding of the primary drivers for purchasing wind energy in the region and the availability of financial incentives. Financial modeling was designed to evaluate the different cost outcomes of developing a plant in the project area with various combinations of available incentives and two potential wind speeds.

At the end of 2011, West Virginia was 20th in installed wind capacity among the United States. Regional demand for wind energy is driven almost entirely by the Federal production tax credit and state renewable portfolio standards (RPSs). Due to its relatively low cost compared to other types of renewable energy, and its availability, wind is the primary non-hydro resource used to comply with most state RPSs.

Overview of the Industry

As of the end of 2010, total installed wind capacity in the U.S. stood at around 40 GW. By the end of March 2012 installed capacity was nearly 49 GW, with an additional 8.9 GW under construction. The year of maximum wind capacity installation was 2009, when 10 GW was added (American Wind Energy Association, 2012). Going forward, the level of installations will depend substantially on

federal incentives, although recent forecasts of global wind power development project a doubling of installed capacity between 2010 and 2014 (Electric Power Research Institute, 2011).

Demand and Supply Trends

Wind energy provided 2.9% of electricity generated in the U.S. in 2011, up from 2.3% in 2010 (Energy Information Administration, 2012). In states with high wind resources wind provides a larger share of electricity. In South Dakota for example, wind generated more than 22% of all electricity produced in the state in 2011 (Energy Information Administration, 2012).

Texas leads in installed wind capacity with 10.7 GW. Iowa, with 4.4 GW, and California, with 4.2 GW, have the second and third largest capacity. Wind installations tend to be higher in the mid-west wind corridor, where output per turbine is higher (Table 16).

Table 166. Installed wind capacity and generation in regional states as of the end of 2011.

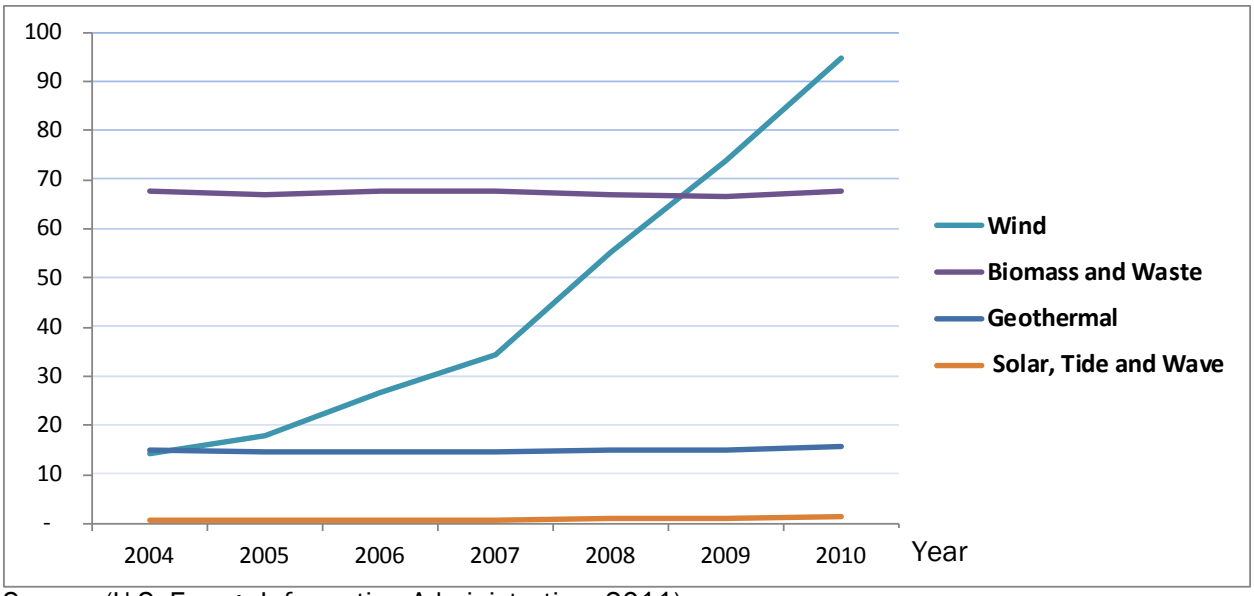
State	Installed Capacity	State Rank in 2011	% of In-State MWh in 2010	% of In-State MWh in 2011
Delaware	2 MW	37th	0.05%	0.04%[1]
Illinois	2.7 GW	4th	2.21%	3.15%
Indiana	1.3 GW	13th	2.34%	2.72%
Maryland	120 MW	28th	0.00%	0.76%
New Jersey	7.5 MW	36th	0.02%	0.02%
New York	1.4 GW	12th	1.90%	2.06%
Ohio	112 MW	29th	0.01%	0.13%
Pennsylvania	789 MW	15th	0.81%	0.86%
West Virginia	584 MW	20th	1.16%	1.39%
[1]Data not published. %age is based on same output as in 2010.				

Sources: (Wind Powering America, 2012; American Wind Energy Association, 2012; and Energy Information Administration, 2012).

Over the last few years a continuing industry trend has been toward larger average nameplate capacity, hub height, and rotor diameter of installed wind turbines (NREL, 2011a). Some of the reason for this is to serve lower-wind-speed sites, which require larger rotor diameters to be feasible. Larger sized turbines have contributed to higher capacity utilization of wind facilities as higher wind speeds can be accessed with taller towers. Average capacity factors have declined somewhat in recent years due to the need to curtail wind output in some electricity markets and development of lower-quality wind in some areas (NREL, 2011c).

The use of recommended processes to more efficiently integrate wind energy into the electricity transmission system is expanding. Ubiquitous recommendations such as consolidated balancing areas, expansion of forecasting, and intra-hour scheduling are being implemented more broadly. The FERC recently mandated that transmission providers offer 15-minute transmission scheduling (FERC, 2012).

Contrary to solar panel supply, wind component supply has trended toward U.S. production rather than away (Figure 47). It is reported that nine of the eleven largest wind turbine manufacturers in the U.S. market had one or more manufacturing facilities in the United States in 2010 (NREL, 2011c).



Source: (U.S. Energy Information Administration, 2011)

Figure 45. U.S. electricity generation by non-hydro renewable resources (billion kWh).

Pricing Trends

Wind turbine prices doubled between 2002 and 2008, and then fell through most of 2011. Since mid-2011 prices have been rising, largely in response to a demand increase tied to expiration of the federal grant program (Lawrence Berkeley National Laboratory, 2011). Total installed costs are a function of turbine capital costs as well as development costs, interconnection costs and construction costs.

The levelized cost of energy (LCOE) is a key metric for evaluating project cost as it calculates the cost of producing a unit of electricity based on a project's total installed costs, including financing, plus operating costs. The LCOE produced from a wind facility ranges from around $60/MWh for onshore systems with high-quality wind to about $152/MWh for offshore systems (Lantz, Hand, & Wiser, 2012), (Electric Power Research Institute, 2011).

Types of Systems

Conversion of wind's kinetic energy into electrical energy is a function of the density of the air, the swept area of the turbine rotor and the velocity of the wind. The power of wind varies proportionally with the cube of the wind speed; thus, a 25% increase in wind speed causes a doubling of the power contained in the wind (EPRI, 2011). This illustrates the root of the continuing trend toward building taller and larger turbines.

Wind turbine generators (WTGs) are an established and widely commercially available technology. What is changing about WTG systems is the ability to include components that make them behave more like conventional generators that also provide essential grid services. Wind facilities are now required to provide low-voltage ride-through during grid faults, and the ability for WTGs to be grid synchronous also exists but is not required.

Other technological trends in WTG components include the increased use of variable-speed turbines and potential use in combination with the ability to provide reactive power to the grid (EPRI, 2011). There is also much discussion about switching from gearbox-powered turbines to direct-drive

generators as a strategy to reduce maintenance requirements, although this is considered an unconventional technology and is still in testing (EPRI, 2011).

Management of wind facility output is becoming more heavily monitored. The use of supervisory control and data acquisition (SCADA) systems is an essential part of operation as facilities must communicate with the grid operator in real-time regarding their availability and production capability. Use of forecasting software is also becoming more important. The Federal Energy Regulatory Commission (FERC) recently ordered wind facilities to share their forecast and status data with transmission providers (FERC, 2012) to smooth the integration process.

Wind Incentives

There are several types of financial incentives available for installing wind systems at the State and federal levels. These include various tax credits tied either to production or capacity, direct grants and loan programs. Several incentive programs that were tied to stimulus funding are no longer available.

Federal Incentives

The Federal Production Tax Credit (PTC) is a corporate tax credit available for electricity generated from wind resources that applies to the first ten years of facility operation. It is currently 2.2 cents per kWh for wind, geothermal and closed-loop biomass systems. The in-service deadline for wind facilities to qualify was December 31, 2012. Other types of resources have an additional year before eligibility expires (Database of State Incentives for Renewables and Efficiency, 2012). The PTC was first enacted by the Energy Policy Act of 1992, which originally applied only to wind energy, closed-loop biomass, and poultry-waste energy resources.

The ARRA of 2009 allowed taxpayers eligible for the federal PTC to take the federal business energy investment tax credit (ITC) or to receive a federal grant instead of taking the PTC for new installations. Like the PTC option, the ITC option is available through December 31, 2012. The grant was only available to systems where construction began prior to December 31, 2011 (Database of State Incentives for Renewables and Efficiency, 2012).

Wind facilities also qualify for the same Modified Accelerated Cost Recovery System (MACRS) 5-year accelerated depreciation schedule as do solar facilities. This allows wind equipment to qualify for a 5-year, double-declining-balance depreciation (Database of State Incentives for Renewables and Efficiency, 2012). Small wind facilities, with capacities of 100 kW or less, are eligible for a separate ITC. The primary incentive is a 30% corporate tax credit per kW of installed wind with no maximum amount.

State Incentives

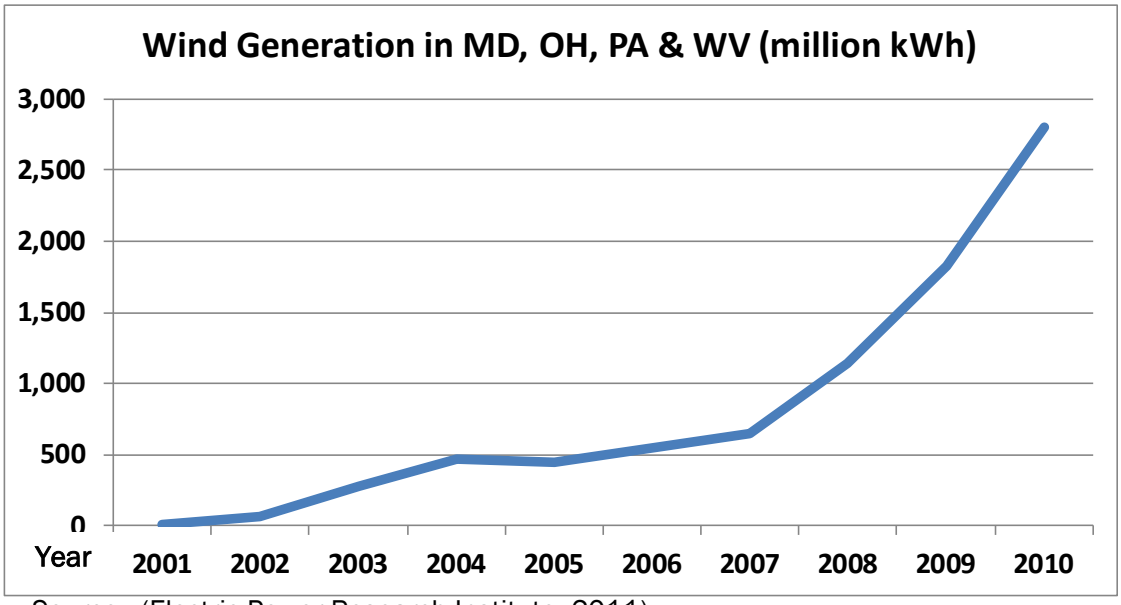
No states have an explicit carve-out for wind energy production as many do have for solar energy production. However, most states in the region have enacted a set of financial incentives directed toward wind development. For utility-scale wind these include exempting wind facilities partially or entirely from property taxes, exempting the purchase of turbines from sales tax and establishing special corporate tax rates. For small-scale wind systems most states have additional incentives, including income tax credits for purchases, and special loan and grant programs through utilities or in some cases the states themselves.

In addition, most states in the PJM region have a RPS which has had some influence on creating buyers for wind-generated electricity. West Virginia provides a partial property tax exemption for commercial wind systems, by allowing a percentage of the facility to be valuated at salvage value. The state has also set special business and occupation (B&O) tax rates for wind output.

Regional Markets for Wind Energy

Regional demand for wind energy is driven almost entirely by the Federal PTC and state renewable portfolio standards. Due to its relatively low cost compared to other types of renewable energy, and its availability, wind is the primary non-hydro resource used to comply with most state RPSs. The recent growth of wind-powered electricity production in the United States, relative to other forms of renewable energy, is illustrated in Figure 47.

Regionally, wind-powered generation has grown similarly, with a pattern that closely matches the national trend. The following figure describes the growth in wind output for the states of Ohio, Maryland, Pennsylvania and West Virginia (Figure 48). As of 2012 there were no utility-scale wind generators in the states of Kentucky or Virginia.



Source: (Electric Power Research Institute, 2011)

Figure 46. Wind generation in Maryland, Ohio, Pennsylvania and West Virginia.

Regional states with renewable and alternative portfolio standards allocate credits for purchase of wind energy to utilities that are required to meet the standards. Credits associated with the output of an individual wind facility may be purchased by multiple states within the region. The following table describes the allocation of wind energy to the eight states within the PJM that have enacted some sort of portfolio standard requiring accounting of renewable energy credits for which wind is eligible, including small residential and commercial systems (Table 17). In some cases the output of a wind facility – such as Beech Ridge in West Virginia - may be allocated to all eight states based on partial purchases of the underlying output credits. Some utility-scale facilities such as Fowler Ridge in Indiana may also be divided into parts, with more than one entry for plants with the same name. For example, West Virginia is one of eight states allocated credits for part of the Beech Ridge project in West Virginia and one out of six parts of the Fowler Ridge project, and is one of seven states allocated credit for purchasing parts of two out of four phases of the Grand Ridge project in Illinois.

Table 17. Number of wind projects included in state portfolio standard accounting.

State	# Wind Projects in Portfolio
Delaware	52
District of Columbia	30
Illinois	126
Maryland	44
New Jersey	80
Ohio	37
Pennsylvania	58
West Virginia	4

Source (PJM, 2013)

Wind Financing

Compared to a couple years ago, the climate for wind financing by the private sector is reported to be improving, including the ability to get a purchase power agreement (PPA) for the output of a facility. The ability to get financing is often dependent on having a PPA in place. It is reported that as of the end of 2010 there were 16 third-party tax equity providers willing to be partners in wind financing deals (National Renewable Energy Laboratory, 2011d).

PPAs have not been available for all plants and some must primarily sell their power in the wholesale market. Within the wholesale market, power prices are not guaranteed at a certain level and the facility thus receives only the locational marginal price for electricity in their area, which varies by time of day and season. Average wholesale power prices for the PJM region have recently been in the range of 3.5 to 4.5 cents per kWh on an annual average basis, as reported by day-ahead trades made by the Intercontinental Exchange (U.S. Energy Information Administration, 2012). This amount is lower than the average of trades reported for 2011.

To date, utilities own or buy power from 64 % of all wind power capacity in the United States, with merchant or quasi-merchant (merchant plants seek revenue from the wholesale electricity market and may engage in short-term financial arrangements to hedge spot market revenues, while quasi-merchant plants also have a minimum revenue guarantee relationship with another firm that covers certain fixed costs (Woodhouse, 2006) projects accounting for 25 % and power marketers 10 % of capacity (NREL, 2011a). Low natural gas prices have suppressed wholesale electricity prices and reduced the number of developers willing to operate as merchant plants (NREL, 2011a).

PPAs for wind plants in the East (defined as the States of Tennessee, Kentucky, North Carolina, Virginia, West Virginia, Pennsylvania, New Jersey, Maryland, Delaware, and New York) averaged about $70/MWh for projects built between 2007 and 2010, and were the third highest compared to other areas in the U.S. The range of prices for nine sampled Eastern projects was $60 to about $86. For the Great Lakes region (defined as the States of Ohio, Michigan, Indiana, Illinois and Wisconsin) PPAs averaged about $62/MWh, with a sampled range of $50 to $108 (NREL, 2011c).

The ability to obtain financing for wind projects in 2013 and beyond will depend on the extension of the federal tax incentives and the nature of the extension. The investment tax credit (ITC) has been a more favorable method of financing compared to the production tax credit (PTC). The presence of the stimulus-funded cash grant option also likely enticed some tax equity partners to participate who would not be interested in the PTC option.

Federal Demand for Renewable Electricity

Wind qualifies for the same credits that solar does under The Energy Policy Act of 2005, which mandates that federal agencies use renewably-generated electricity in amounts not less than 7.5%

in fiscal year 2013 and each fiscal year thereafter (Cory *et al*., 2009). This qualification includes double credit for every kWh of wind energy generated onsite of a federal facility. However, the site chosen for wind analysis in this project is not federal property.

Geothermal

Scientific Report on Geothermal Potential in West Virginia

A scientific report completed by Southern Methodist University, funded by a grant from Google.org, identified West Virginia as an area of high geothermal potential relative to the East Coast (Blackwell, Frone, & Richards, 2012).

SEP Marketing Plan and Activities

Marketing for the development of a SEP on mine-scarred land in Appalachia is multi-faceted and includes generating market data for specific alternative energy types on specific sites which can be presented and discussed as a viable opportunity for redevelopment of former mine sites (brownfields) as SEPs.

Project Marketing Activities: Presentations and Meetings

The Market Strategy includes making presentations to local, regional, and national groups. Presentations and events where this project was highlighted are described below.

SEP Showcase - 2012

The Sustainable Energy Park Showcase Event was held on September 5, 2012, at Glade Springs Resort and Conference Center in Beckley, West Virginia. Titled the "Renewable Energy Showcase," this event was a major component of the 2012 West Virginia Brownfields Conference with over 175 participants. The agenda for the Conference is provided below (Figure 49).

Figure 47. 2012 West Virginia Brownfields Conference Agenda.

During the conference a panel of project stakeholders presented project results along with a brief background on the processes. Master plan visualizations were delivered through: Poster layouts describing the planning process, planning narrative, plans, sections and illustrative drawings; animated fly-through visualizations; and digital three-dimensional model in compatible formats. A short video of the highlights of the proceedings is included as a CD attachment found in Appendix M.

Annual West Virginia State Brownfields Conferences

The West Virginia Brownfields Conference is the statewide event that combines exceptional educational programs with outstanding networking opportunities between communities, development professionals and service providers. The conference is hosted annually by the West Virginia Brownfields Assistance Centers at West Virginia University and Marshall University in cooperation with the WVDEP, West Virginia Development Office, the Air and Waste Management Association as well as event sponsors. The audience attending the annual State Brownfields conferences includes community stakeholders, state agencies, federal agencies (including NREL), interested developers, bankers, legal/attorneys, local government officials, and private businesses. The conference is typically a 2-day event held in a different part of the state each year. It is the largest Brownfields gathering in the state.

Continued educational efforts included a presentation on the SEPs project at the 2009 West Virginia State Brownfields Conference, Morgantown, West Virginia, September 1, 2009. In addition, outreach was provided to landowner and mining stakeholder groups through other conference presentations.

Project researchers from Marshall University presented project findings related to SODAR wind readings at sites within West Virginia at the 2010 State Brownfields Conference in Charleston, West Virginia, September 8, 2010.

On September 14-15, 2011 in Morgantown, West Virginia, 160 attended the 2011 West Virginia Brownfields Conference where this project was featured as part of a Poster Session. The display focused on the project's conceptual ideas as well as progress to-date including the GIS database, and economic analysis of the Park's components. As West Virginia and the nation look to move beyond coal and to sustainable energy forms, this project continues to generate local and regional interest.

2011 National Brownfields Conference

Project researchers attended the National Brownfields Conference in Philadelphia, Pennsylvania April 3-5, 2011. A project presentation was made and flyers on the project were disseminated. In addition, a special session for West Virginia delegates was held and over 50 attended. A poster was also developed and displayed as a visual aid in the West Virginia Section of the Region III booth at the Conference.

West Virginia Wind Group Meeting - 2010

Project staff attended the West Virginia Wind Group Meeting held on October 19, 2010, at Canaan Valley Resort and Conference Center. Project staff participated in networking opportunities with participants to discuss project progress being made on the portfolio of SEP sites. Project staff also benefited from discussions with private sector wind companies, and communities in attendance regarding their future participation in the development of a SEP.

Geothermal Energy Expo 2010 Conference and Expo

Project staff joined the West Virginia Division of Energy to be a part of the West Virginia Delegation for the Geothermal Energy Expo 2010 Conference October 24-27, 2010, in Sacramento, California. More than 2,500 attendees from 42 different states and 13 different countries came together in Sacramento for the annual Geothermal Energy Association (GEA) Geothermal Energy Expo, the largest gathering of geothermal energy leaders in the world. This was an opportunity for the project staff to learn about the possibility of including geothermal as another possible alternative energy source on mine-scarred land and for use in the SEP.

West Virginia Governor's Energy Summit - 2010
On December 7, 2010, project staff attended the West Virginia Governor's Energy Summit at Stonewall Resort and Conference Center in Roanoke, West Virginia. During this event, project staff met with industry and regulatory stakeholders to discuss how to engage industry (coal and natural gas) sectors related to the development of SEPs. The coal and natural gas sectors play an important role due to land leases and mineral rights.

Energy Research Open House at West Virginia University – 2010
On December 10, 2010, project researchers set up a project poster at a West Virginia University Energy Research Open House held at the National Research Center for Coal and Energy at West Virginia University. The audience consisted of academia, private consultants, and industry personnel.

World Construction Energy Group
In June 2010, project researchers had multiple meetings with the World Construction Energy Group regarding the potential use of a brownfield location in Hampshire County for a biomass facility utilizing switchgrass as a feedstock. The switchgrass to be used as a feedstock in this situation was planned to be grown on privately held mine-scarred land in the Hampshire Hill area of Hampshire County. As of this final report, the World Construction Group has not contacted our research team since seeking additional project financing.

Land Use Planning Workshop - 2009
Researchers met with Jeff Wood, West Virginia Division of Energy (WVDE), September 23, 2009, regarding which counties have Land Use Master Plans (LUMPs) in place versus which counties need plans. Researchers reviewed plans and assisted counties in the development of these plans. Information related to potential sites with energy-based economic development on mine-scarred lands opportunities were used in this study. A Land Use Planning Workshop to assist county representatives in need of a plan was held December 9, 2009, at the Bridgeport Conference Center in Bridgeport, West Virginia.

Project researchers have researched LUMP legislation and compiled documents for distribution to agencies responsible for individual counties. In addition, data has been collected on each county to be added to each county LUMP. A two page document has been prepared that lists frequently asked questions and summarizes the purpose of a LUMP, how it benefits a county, and what is contained within a LUMP. A LUMP template has also been created including a table of contents and all required sections of a complete LUMP. Instructions have been included in each section to be completed by the county. Multiple sections have been completed including county wood byproduct data, wind data, surface mine data, and county road data.

Site-specific Market and Environmental Studies
The following studies examine the markets for each sustainable energy type at the site level in West Virginia. This information will provide potential investors more detailed information about the opportunities in Appalachia, including the McDowell County Pilot site.

Site-specific Market Study - Biomass
Biofuel is an underutilized energy resource throughout the U.S. and one that could contribute toward meeting societal goals of ecological sustainability and increased energy independence. Overall benefits to a rural community of producing biofuel are increased economic activity, improved air quality through carbon sequestration, improved water quality through nutrient absorption, and land reclamation through soil build up. If reasonable yields can be established, it is also a good use of low-cost marginal land. Researchers evaluated the potential for biofuel establishment and yields on marginal lands at the former McDowell County Indian Ridge former mine site in southern West Virginia.

Project Overview: McDowell County Indian Ridge Site

The former mine site, Indian Ridge, was identified for initial evaluation of biofuel growth potential. The Indian Ridge surface operation, located northeast of Welch, West Virginia was a large mining complex operated by Justice Highwall Mining, Pinnacle Mining Company, and other operators. The mining permits were held under the following companies: Shannon Pocahontas Mining Company, Tug Valley Coal, Kentucky Fuel Corporation, Southern Minerals Inc, and Pinnacle Mining Company. The facility names that were available from the WVDEP's Division of Mining and Reclamation mining permit boundaries file included: Puncheoncamp Thin Seam Mine, Puncheoncamp Thin Seam Mine #2, Upper Shannon Branch Mine, and Upper Shannon Branch Mine Mine #2. A majority of the permits within the Indian Ridge property boundaries are listed as completely released or under a Phase I release, with a few listed as new or renewed permits.

The total acreage for the McDowell Indian Ridge site is approximately 5,692 acres based on parcel data provided by the McDowell County Economic Development Authority. When the initial site screening was conducted, the McDowell County site was included in the list of 612 Candidate sites. We then applied these criteria from our biomass market studies:

- Minimum Open land >10 acres
- Slope 10-15%
- Distance to Processing Facility <150 miles
- Distance to Road < 5 miles

When taking into account the biofuel screening criteria that can be found in the Prioritization Tool, the site shows approximately 224 acres available for biomass, which could potentially yield 1,344 tons of biomass per year. Funding for a potential pilot study on the Indian Ridge site in McDowell County, West Virginia to plant switchgrass and Arundo has been leveraged from the WVDEP and the Appalachian Regional Commission (ARC) through the West Virginia Division of Energy. A subset of the total available 224 acres is being planned for planting in the spring of 2013.

Additional Market Information from a Market Analysis at Other Sites

The results from the findings of the site specific study of biomass at the Indian Ridge site have been supplemented with results from a similar study at the Coal-Mac mining location in Holden, West Virginia and at the Alton site in Upshur County, West Virginia. An abandoned mine site, Coal-Mac, was identified early in the project for initial evaluation of biofuel growth potential. The Coal-Mac surface operation, located in Holden, West Virginia is a large mining complex operated by Arch Coal, Inc. There are several active and released permits within the site boundaries. Researchers utilized several acres on the Phoenix III permit area for the purposes of this project. An area of freshly placed brown soil material was used for Arundo plantings as it would closely mimic the post mining conditions at the Indian Ridge site. As switchgrass generally takes three years to fully establish, the WVDOE and WVDEP leveraging was essential to provide the sufficient data to fully evaluate growth potential on mine-scarred lands.

The area available for plot set-up and soil sampling at Coal-Mac was approximately 9 acres. The plot area was situated on a flat spot in the middle of a previously active surface mine. The area available for plots was bare soil that had been shaped to a flat area with no plant establishment. See Figures 50 through 52 for examples of biomass plantings on former surface mines.

Figure 48. Planting of biomass crops at the Coal-Mac site, Holden, West Virginia.

Figure 49. Biomass crop at the Coal-Mac site after 1 year, Holden, West Virginia.

Figure 502. Switchgrass crop, 4-years after planting at the Alton site, Upshur County, West Virginia.

Soil samples were collected at each of the sites in an effort to determine baseline conditions. The sites were averaged and the results can be seen in Table 18.

Table 18. Soil samples collected at the Coal-Mac site are indicative of freshly placed mine soils in southern West Virginia.

			Lbs / acre				Meq / 100 g					% Saturation					
Sample ID	Sample Date	pH	P	K	Ca	Mg	K	Ca	Mg	H	CEC & BS	K	Ca	Mg	H	CEC & BS	% OM
CM 1-1	5/3/2011	5.4	25	150	188	115	0.2	0.5	0.5	2.6	4	5	13	13	70	31	0.35
CM 1-2	5/3/2011	5.6	33	144	272	185	0.2	0.7	0.8	1.8	3	5	20	22	52	47	0.32
CM 1-3	5/3/2011	6.6	41	159	1405	340	0.2	3.5	1.4	0	5	4	68	28	0	100	1.15
CM 1-4	5/3/2011	5.9	41	192	751	401	0.2	1.9	1.7	2.6	6	4	29	26	41	59	1.41
CM 1-5	5/3/2011	5.5	36	158	382	205	0.2	1	0.9	2.6	5	4	21	19	56	44	0.41
CM 2-1	5/3/2011	5.4	33	167	372	157	0.2	0.9	0.7	2.6	4	5	21	15	59	41	0.41
CM 2-2	5/3/2011	6.3	44	178	1151	292	0.2	2.9	1.2	1.8	6	4	47	20	29	71	1.15
CM 2-3	5/3/2011	6.1	38	200	985	414	0.3	2.5	1.7	2.6	7	4	35	24	37	63	0.93
CM 2-4	5/3/2011	6.4	50	200	1217	480	0.3	3	2	1.8	7	4	43	28	25	75	1.56
CM 2-5	5/3/2011	6	44	174	580	254	0.2	1.5	1.1	0.8	4	6	41	30	23	77	0.35
CM 3-1	5/3/2011	5.4	5	49	472	189	0.1	1.2	0.8	2.6	5	1	25	17	56	43	0.72
CM 3-2	5/3/2011	7.1	45	58	1123	302	0.1	2.8	1.3	0	4	2	68	30	0	100	1.10
CM 3-3	5/3/2011	5.4	12	63	692	263	0.1	1.7	1.1	3.8	7	1	26	16	57	43	1.23
CM 3-4	5/3/2011	5.4	6	58	538	252	0.1	1.3	1	2.6	5	1	27	21	51	49	0.86
CM 3-5	5/3/2011	5.4	5	55	553	211	0.1	1.4	0.9	3.8	6	1	23	14	62	38	0.76
Average		**5.9**	**30.5**	**133.7**	**712.1**	**270.7**	**0.2**	**1.8**	**1.1**	**2.1**	**5.2**	**3.4**	**33.8**	**21.5**	**41.2**	**58.7**	**0.8**

Site-specific Market Studies – Solar

Researchers evaluated potential project economics and estimated operating costs and potential revenues from electricity sales from a solar array. Costs were evaluated using expected capital and operating costs. Two financing structures were evaluated: A commercial net-metering project and a third-party power purchase agreement project. The commercial net-metering project is considered to be more realistic given current market conditions.

Project Overview – McDowell County Site

The project site selected for the evaluation of solar markets is a large surface mining area in McDowell County comprised of several connected permitted areas, some of which are active and some inactive. The project area contains ample acreage to site a medium or large-scale solar facility. PV projects in general need about 5 to 10 acres per MW. A 650 KW DC project would thus need 4 to 6.5 acres for the combined collector area plus a staging area for installation and maintenance. A 2 MW DC project would require 10 to 20 acres for collection. Figure 53 shows an illustration of the project area in proximity to existing power lines.

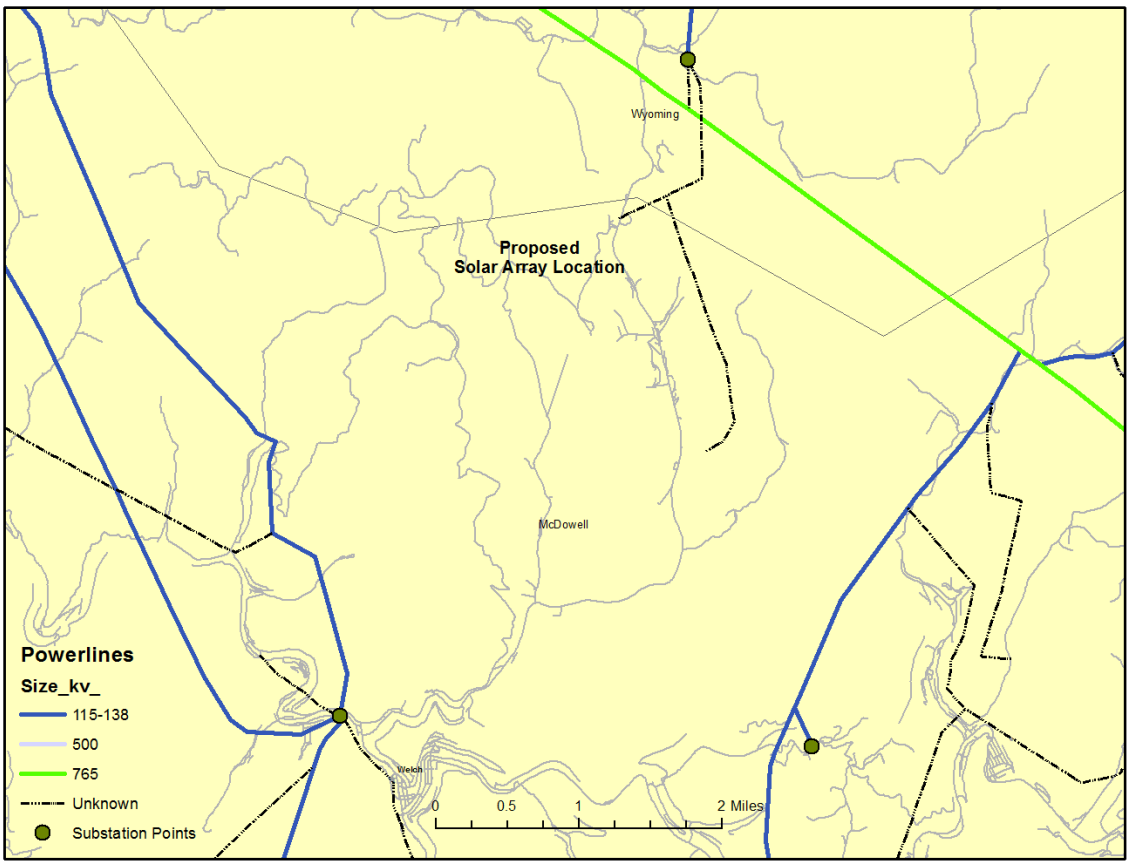


Figure 51. Proposed solar array location in proximity to area power lines for a surface mine site in McDowell County, West Virginia.

This analysis evaluates two potential projects representing two primary types of ownership:

1. A 650 kW net metering project owned by a local or federal entity – The primary entities are the McDowell County Economic Development Authority and the Bureau of Prisons, which operates a FCI on the property.

2. A 2 MW commercial power purchase agreement (PPA) project owned by a private developer - This financing model is a "third-party" ownership model, which requires a separate, taxable entity to procure, install, and operate the solar PV system on a consumer's premises, in this case the Bureau of Prisons or an out-of-state entity. The PPA is a long-term contract to purchase 100% of the electricity generated by the system from the system owner/third-party (National Renewable Energy Laboratory, 2011c).

The primary benefit of the net metering arrangement is that it is already cleared with the State of West Virginia and its utilities as a legitimate way to obtain revenue from investment in a solar array, provided that the interconnection standards are met.

The primary benefits of PPA financing are: No or low up-front costs, ability for a tax-exempt entity to purchase solar-powered electricity at lower prices due to savings passed on from federal tax incentives, a predictable cost of electricity over the length of the PPA, avoidance of effort related to system design and permitting, and no operating and maintenance responsibilities (NREL, 2011c).

Site Potential Screening Characteristics

The EPA's RE-Powering America's Land Initiative defines a process for screening a potential solar PV development site for physical and financial feasibility. The process includes pre-screening, site screening and financial screening considerations. The McDowell County site characteristics are largely favorable although the solar insolation is only fair and there are no state or local financial incentives to develop solar resources. The project's distance from a low-voltage transmission line may add costs, depending on where the array is actually located.

The McDowell County site fares well when evaluated against the initiative's pre-screening site characteristics as it receives more than the 3.5 kWh/m^2/day of solar insolation and much of the acreage is located less than one mile from a graded road. The array could be located within one mile of a low-voltage transmission line but may be more than one half mile away and thus needs further evaluation. The property has more than two un-shaded acres available for a ground mounted system with a slope of less than six degrees. As the property is quite large, there are several options for positioning the array to avoid any obstacles.

The site also fares well with other screening characteristics such load assessment. The Federal FCI could likely utilize a large portion of electricity generated by an array with a maximum output of 500 kW. The FCI currently pays 8.42 cents/kWh for electricity during peak hours, which meets the minimum retail price of 8 cents/kWh recommended as a cut-off price. The site does not fare well with regards to financial screening due to the lack of utility or other state-based incentives for PV.

Solar Resources in the Project Area

Solar insolation in West Virginia is somewhat low compared to other places in the United States. Solar insolation in select cities can be found in Table 19 below. Southern West Virginia does have slightly higher insolation than the northern part of the state, but the region receives only about two-thirds of the average levels seen in parts of the southwest. The average radiation of the area is about 4.72 kWh per m^2 per day. On an annual basis the radiation is expected to be 1,475 kWh per m^2. Some areas in the vicinity may receive slightly higher insolation.

Table 19. Solar insolation in select cities of the United States.

Area	kWh/m²/day		Area	kWh/m²/day
Las Vegas, Nevada	6.31		Welch, West Virginia	4.72
San Diego, California	5.68		Charleston, West Virginia	4.55
Austin, Texas	5.24		Cleveland, Ohio	4.31
Atlanta, Georgia	5.03		Buffalo, New York	4.09
Philadelphia, Pennsylvania	4.75		Seattle, Washington	3.67

Source: (NREL, 2012).

Figures 54 and 55 depict expected monthly output for the model arrays as calculated by PVWatts and the System Advisor Model (NREL, 2011d). The peaks in the chart show that maximum output is expected in the months of May and September. A 650 kW PV system would thus generate about 738,000 kWh in the first year, for a capacity factor of 13%, and decline by about 0.5% each year thereafter with normal system degradation.

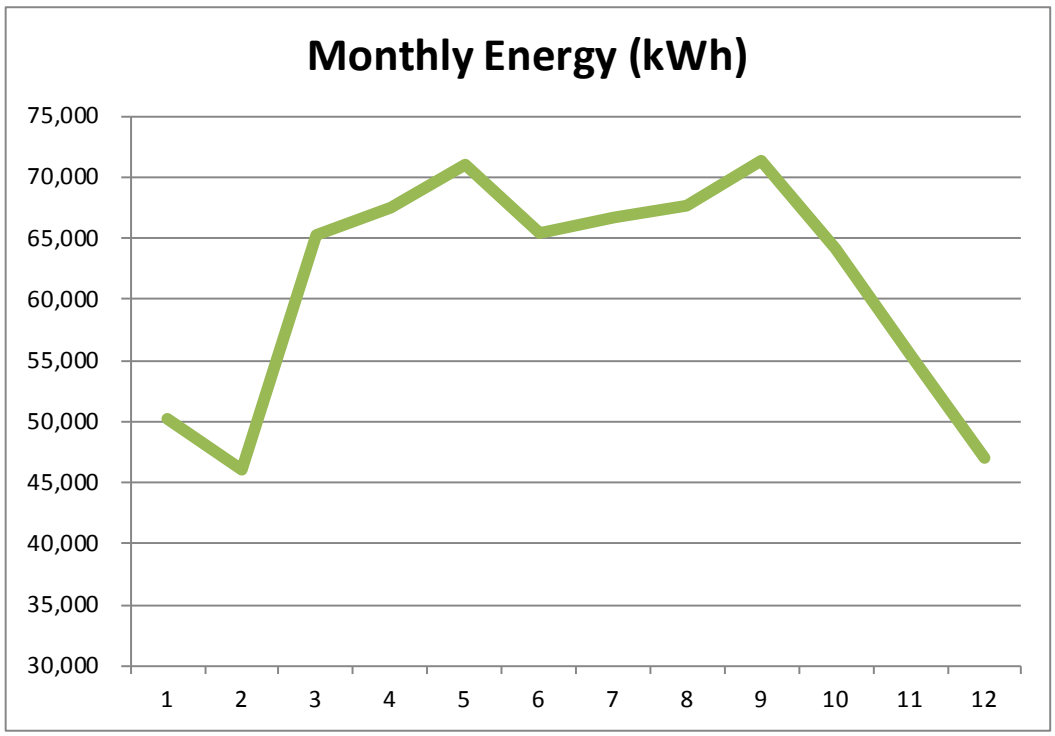


Figure 52. Expected monthly output for a 650 kWDC solar array system (kWh).

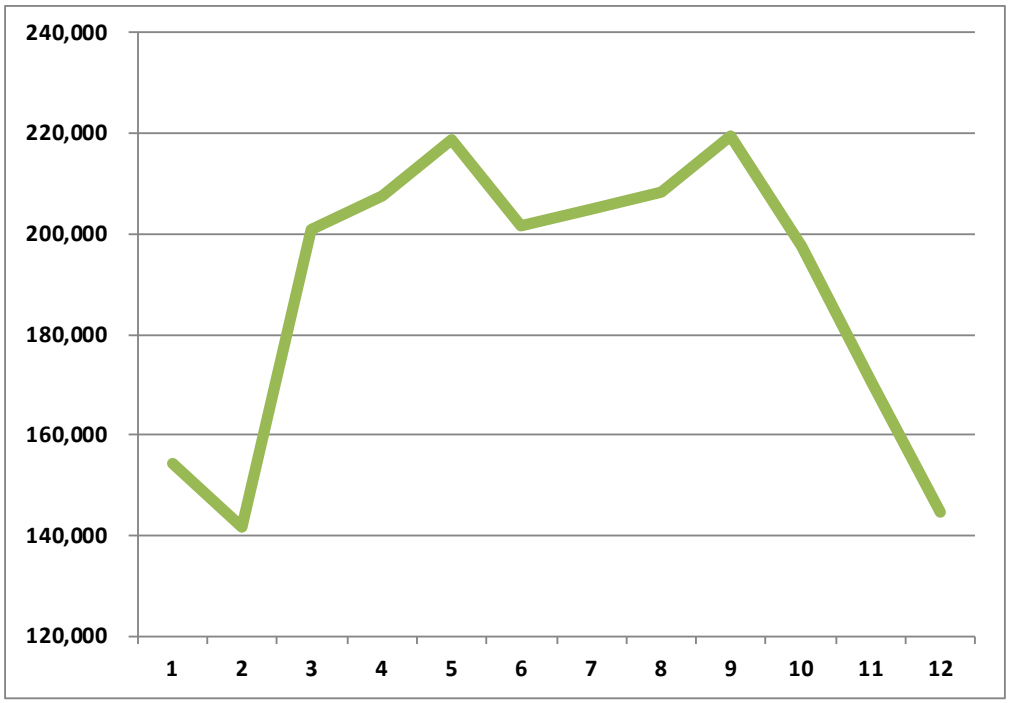


Figure 53. Expected monthly output for a 2 MW solar array system (kWh).

Financial Analysis

This analysis describes potential financing arrangements for the two ownership and financing arrangements and estimates the cost of electricity produced from the facility at the McDowell County site. The System Advisor Model (SAM), designed by NREL, was chosen as the software for evaluation. The SAM is an accounting model that incorporates a number of financial conditions and calculates the levelized cost of electricity (LCOE).

Assumptions for Commercial Net Metering Arrangement

This analysis simulates the cost of electricity produced by PV system financed, owned and operated by the McDowell County EDA in the absence of federal or state incentives. The EDA cannot utilize tax credits on its own due to its tax-exempt status (McDowell County EDA, 2010).

1. Utility Rate
    a. Rates escalate by 3% per year, slightly above the rate of inflation.
    b. The net metering buy-back rate is modeled at the Bureau of Prison's electricity rate of 8.42 cents/kWh.
    c. It is assumed that the system owner is able to sell all electricity generated, or to avoid purchasing that amount of electricity.
    d. The system owner is able to take advantage of time-of-use (TOU) pricing.
2. Financing
    a. The analysis period is 30 years, representing the expected life of the PV system.
    b. Real Discount Rate – This variable reflects the perceived opportunity cost of other potential investments and is modeled at 2%.
    c. The McDowell County EDA is exempt from Federal and most state taxes, including sales tax. Insurance on the system is modeled at 0.5% of installed costs, the SAM default level.
    d. Property tax is assumed to be zero.

    e. Commercial loan parameters – The McDowell County EDA is assumed to be able to receive a zero interest loan to purchase the system, such as those funded through clean renewable energy bonds (CREBs).
3. Tax Credit Incentives
    a. With the EDA ownership structure and in the absence of innovative financing, such as use of new markets tax credits, the Federal tax credits cannot be taken.
4. Payment Incentives
    a. Production Based Incentive (PBI) – Potential revenues from SREC markets range from a realistic 0.01 to 0.03 $/kWh from Ohio or Pennsylvania markets to a much less realistic 0.20 $/kWh. Ranges of SRECs prices are modeled as scenarios: 1 to 5 cents/kWh up to 16 to 20 cents/kWh. This payment is received on top of the net-metering payment as the PV system owner retains the rights to the environmental attributes of output.
5. PV System Costs
    a. Direct Capital Costs – modeled at $2.93/watt (module + inverter) for the 650 kW system
    b. Indirect Capital Costs – modeled at $550,000 for permitting, environmental studies, grid interconnection and land preparation.
    c. Land Costs – modeled at zero, due to ownership of the property by the McDowell County EDA.
    d. Total Installed Costs – for the 650 kW system are assumed to be $5.19/Watts direct current (Wdc), slightly below the average cited in Lawrence Berkeley National Laboratory's latest report for non-profit projects of this size.
    e. Operation and Maintenance Costs - $20/kW/year, SAM default values.

Results for Commercial Net Metering Scenario

The analysis of this scenario identified the payback achievable with various combinations of financial incentives. The required payback will depend on the investment opportunities of the system owner to be. This analysis of the scenario also answers the question "What level of incentives causes the project to at least break-even, i.e. achieve a net present value of zero or higher, in 30 years?" As the likely owner under this scenario is a non-profit entity the only incentive available, other than net-metering payments, is SREC payments, which are not guaranteed at any specific level. The payback period is thus highly uncertain.

As shown in Table 20 below, the project would have to receive a production based incentive or SREC of more than 18 cents per kWh in order break even. While SRECs in the 16 to 20 cent range have at times been received by solar PV systems in West Virginia that sell credits to other states, it is risky to assume the ability to receive such a payment, especially for the entire 20-year time period modeled here. Thus, it is likely that the project would not break even within 30 years.

Table 200. Commercial net metering arrangement results.

Solar Renewable Energy Credit (SREC)	Nominal LCOE (cents/kWh)	Payback Period	Net Present Value @ 2%
1 to 7 cents/kWh	22 to 27	> 30 years	Negative
7.5 to 12.5 cents/kWh	18 to 22	25 to 30 years	Negative
13 to 17.5 cents/kWh	14 to 18	20 to 25 years	Negative/ Positive with 15¢ SREC
18 to 20 cents/kWh	10 to 14	18 to 20 years	Positive
[1]This is a very low discount rate. A preference for a higher rate would increase the opportunity cost of the project. The 2% real discount rate (4% nominal rate) is the federal rate published under a revision to OMB Circular No. A-94 titled "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs."			

Assumptions for Third-Party PPA Arrangement

The analysis of this scenario simulated the cost of electricity produced by a PV system financed, owned and operated by a private, tax-paying third-party. The entity is assumed to be able to take advantage of the available federal tax credits for purchasing the system but it may not be able to take advantage of net metering because it does not operate a physical location at the site.

1. Utility Rate
    a. This structure does not utilize net metering as the system owner does not operate a business at the site.
2. Financing
    a. The loan term is 15 years and the analysis period is 30 years, even though the PV system could last up to 80 years (Crowdis, 2012).
    b. All taxes apply.
    c. Real Discount Rate: Three different discount rates (4%, 6%, and 8%) are modeled to show the range of rates that would produce a project with a positive NPV. This variable reflects the perceived opportunity cost of other potential investments.
    d. Commercial loan parameters – 50/50 debt/equity financing; 15 year loan; 7% interest rate.
    e. Property Tax – Solar facilities are Class 3 property and taxed at 0.802 %. Only the capital portion of installed costs is assessed (at 75% of its value), amounting to about 50% of installed costs.
    f. Power purchase agreement (PPA): the SAM model solves for this amount to meet the specified internal rate of return (IRR); the price is assumed to escalate at 1% per year.
3. Tax Credit Incentives
    a. Production Tax Credit (PTC) – It is assumed that the ITC is the preferred incentive and will be chosen over the current 2.2 cents/kWh PTC as it is an up-front payment. The incentives amount to $2.6 million.
4. Payment Incentives
    a. Production Based Incentive (PBI) – SRECs are assumed to be claimed through the PPA. Thus, no additional PBI is available and the PPA is the sole source of revenue.
5. PV System Costs

a. Direct Capital Costs –the 2 MW system is modeled as costing $1.86/Wdc (module + inverter)
b. Indirect Capital Costs – modeled at $650,000 for permitting, environmental studies, grid interconnection, land preparation and state sales tax.
c. Sales tax – A tax rate of 6 % applies to direct costs.
d. Total Installed Costs – modeled at $3.90/watt (Crowdis, 2012).

Results for Commercial Third-Party PPA Scenario

For the third-party PPA scenario the SAM answers the question "What combination of incentives and PPA level provides for an IRR of at least 8%?" An IRR of 8% is often a minimum level of acceptable return. Two levels of return, 8% and 10% are modeled to show the different PPA levels that would be required.

The selected discount rate is important as it represents the opportunity cost of the project. The three discount rates modeled may be considered low by private sector standards; they were selected to illustrate what would be required at the low end of the spectrum of reasonable return. This consideration reduces the viability of the project if the actual desired discount rate is greater than 8%. As shown in Table 21, if an IRR of 8% is achieved the real discount rate of the investor must be no higher than 4% which is quite low for private sector investments. Use of a discount rate greater than 8% would require a project IRR of more than 10% and thus a PPA of more than 22.7 cents/kWh.

Table 21. IRR for third-party purchase scenario.

Internal Rate of Return	Real Discount Rate	PPA Price (cents/kWh)	LCOE Nominal (cents/kWh)	Net Present Value
8%	4%	20.7	22.8	Positive
8%	6%	20.7	22.6	Negative
8%	8%	20.7	22.3	Negative
10%	4%	22.7	25.1	Positive
10%	6%	22.7	24.8	Positive
10%	8%	22.7	24.6	Negative

The primary difference between the two scenarios is the value of the energy produced given the varying PPA prices.

<u>Employment Impact</u>

The primary direct economic impacts associated with a solar facility would be seen during the construction phase. The area would not receive any impact from manufacturing of the solar panels. The majority of the construction impact would be from installation labor and support services as well as wholesale trade. During the operating phase the facilities would require only one full-time person, or less. These estimated impacts are described below and are based on the JEDI model (NREL, 2011b).

1. 650 kW facility
   - Construction phase: 16 direct construction jobs + 15 indirect support jobs + 7 induced jobs for a total of 38 temporary jobs.
   - Operating phase: 1 part-time job
2. 2 MW facility

- Construction phase: 51 direct construction jobs + 45 indirect support jobs + 21 induced jobs for a total of 117 temporary jobs.
- Operating phase: 1 full-time job

Non-Market Impacts

While the direct economic impacts of the facility to McDowell County will be small following construction, there may be additional benefits to the community that are difficult to measure. These include productive use of marginal land that would otherwise be unused and maintenance of that land for future uses, community experience with an emerging technology and social benefits of being seen as progressive in deploying an emerging technology. Emissions benefits from displacing fossil-fuel fired generation will exist, but these will occur at an uncertain level and, due to the regional nature of power plant emissions, with benefits that may or may not be felt in the project area.

Solar energy does displace conventional fossil-fired generation, but it is uncertain how much emissions will be avoided as the fuel displacement is usually not one to one. Presently there is no standard in place that can be used to estimate the emissions avoided by use of variable resources, such as wind and solar, to produce electricity. It has been argued that the effect of an input of electricity from a renewable generator, such as wind or solar, on other generators such as coal or natural gas is difficult to quantify (Federal Trade Commission, 2012). Some of the reason for this is because grid-connected solar PV systems have varying and uncertain output during cloudy weather. In a 2008 study, Carnegie Mellon University concluded that solar PV systems have a larger magnitude of power output fluctuation than wind energy and that the costs of large scale solar PV integration are thus likely to be larger than those of wind (Apt and Curtright, 2008).

Site-specific Market Study - Wind

Researchers evaluated energy potential and economics for the Indian Ridge site in McDowell County, West Virginia through site characteristics and screening criteria. It was determined that for medium- to high-speed wind turbines, the site is not viable for wind energy.

Project Overview – McDowell County Indian Ridge Site

The selected Indian Ridge project site in McDowell County is a former surface mining area. It met the site characteristics and screening criteria for available land, distance to transmission lines, and distance to roads. However, the wind resource potential, at 4.6 m/s at 80m, was too low for the site to be viable for wind energy for medium- to high-speed turbines. A wind speed of at least 5.5 m/s at 80m turbine height must be present for a property to be considered for medium- to high-speed turbines. The site may still be considered a candidate dependent on the availability of turbines capable of utilizing low-speed wind and additional research on viability.

If interest exists, the wind resource potential could be measured by an anemometer to obtain a more site-specific measurement of the wind speed, which will determine if the wind resource potential is above or below the required 5.5m/s at 80m wind speed.

Non-Market Impacts

If turbines are placed on the property, the direct economic impacts of the facility to McDowell County will be small following construction and there may be additional benefits to the community that are difficult to measure. These include productive use of marginal land that would otherwise be unused and maintenance of that land for future uses. Emissions benefits from displacing fossil-fuel fired generation are also likely to exist, but these will occur at an uncertain level and, due to the regional nature of power plant emissions, the benefits may or may not be realized in the project area.

Wind energy does displace conventional fossil-fired generation, but it is uncertain how much emissions will be avoided as the fuel displacement is not always one to one. Presently there is no standard in place that can be used to estimate the emissions avoided by use of variable resources,

such as wind and solar, to produce electricity. It has been argued that the effect of an input of electricity from a renewable generator, such as wind or solar, on other generators such as coal or natural gas is difficult to quantify (Guides for the Use of Environmental Marketing Claims, 2012).

Due to the high quality wind potential along the Allegheny Front on the eastern edge of the Appalachian highlands, in Grant County, West Virginia, researchers evaluated potential project economics, including operating costs and potential revenues from sales of electricity produced by a potential wind facility at the site. This analysis comprises financial modeling that compares the different outcomes of developing a plant in the project area using the two available federal incentives, the ITC and the PTC, and two potential wind speeds.

Project Overview – Grant County Site

The selected project site in Grant County is a former surface mining area. The project area contains enough acreage to site two to four turbines, with a three-turbine array selected for analysis. The modeled turbine layout is shown below in Figure 56, with each turbine 500 meters apart on a north-south line and 750 meters apart on an east-west line. The actual array selected will need to be based on more detailed engineering assessment of the property and actual meteorological readings on the site. The property has three significant physical constraints that may limit the number of turbines to two: a rail line comprising the northern border of the property, a state road comprising the southern and eastern border, and an east-west high-voltage transmission line traversing the center of the property.

This analysis evaluates one potential project representing a 6 MW wind facility owned by a wind developer or local/developer partnership. The array is comprised of three 2 MW turbines.

Presently, no anemometer exists on the property although significant assessment efforts have taken place in the area. Truepower estimations indicate that the best wind resources, those between 7 and 8 m/s, are located in the most western, southern and eastern sections of the property. The center part of the property is estimated to have wind resources of between 6 and 7 m/s.

Figure 54. Modeled turbine layout at the Grant County, West Virginia site.

Wind Resources in the Project Area

The wind resources in the project area are in the range of 6 to 8 meters/second (m/s) at an altitude of 80 meters on an average annual basis (AWS Truepower, 2010). This falls in the range of typical minimum resources worthy of further investigation. Many developers seek average wind speeds of at least 7 m/s at hub height. The resource is modeled at two potential average wind speeds - 7.3 m/s and 7.7 m/s - at an altitude of 100 meters, which represents the higher height of the newer towers. The expected output of the facility is shown in Figure 57 below. On an annual basis the capacity factor of the facility is expected to be around 29%. A full wind resource assessment would need to be conducted prior to investing in this site.

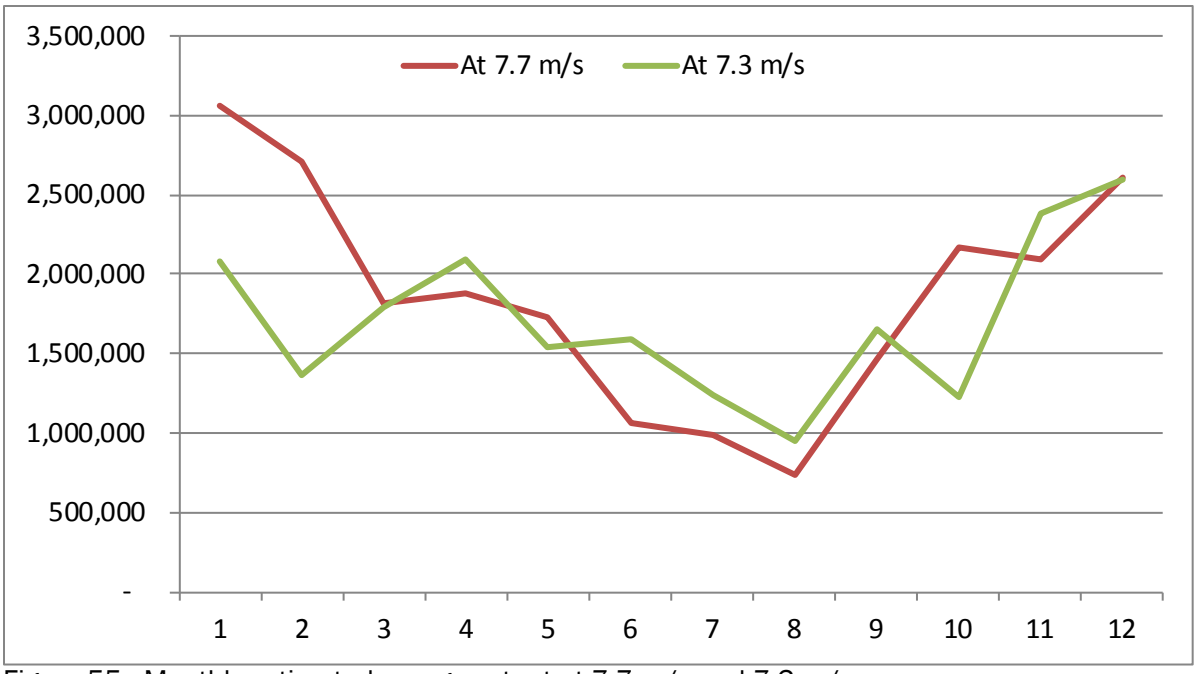


Figure 55. Monthly estimated energy output at 7.7 m/s and 7.3 m/s.

Financial Analysis

The facility is modeled as being able to receive the average sampled regional PPA price of $75/MWh. Results are compared for the two selected potential wind speed levels of 7.3 meters/second and 7.7 meters/second at an altitude of 100m. These levels of output are also compared with and without the ability to receive the federal PTC. Key financial metrics compared are net present value (NPV) and internal rate of return (IRR). A scenario where the facility operates as a merchant power plant is not modeled due to the lower price that would have to be received in the wholesale market.

Assumptions

6. Financing
    a. The analysis period is 25 years, representing the expected life of the turbines.
    b. Property tax incentives apply, with 53% of the facility taxed at salvage value. The property tax rate modeled is the Class 3 tax for Grant County of 80.2 cents per $100 of value.
    c. Commercial loan parameters: 10-year term; 6.5 % interest; 50/50 debt to equity.
7. Tax Credit Incentives
    a. Two scenarios are modeled, one with the upfront Federal Investment Tax Credit of 30% and one with the Federal PTC of 2.2 cents per kWh for ten years.
8. WTG System Costs
    a. Turbine costs are modeled at $1,800/kW.
    b. Total Installed Costs are modeled at $2,064 per kW, about the average observed for 2011 installations (National Renewable Energy Laboratory, 2011a), for a total cost of $16.5 million.
    c. Land Costs – modeled at zero. The property is owned by the Grant County EDA.
    d. The developer pays royalties to the EDA in the amount of $2.25/MWh, which amounts to $44,000 or $48,000 per year (Royalties may be paid per unit of generation (kWh or MWh) or may be based on capacity.

Results

The following results describe the estimated IRR that a project developer would receive with a PPA of $75/MWh under the two average wind speed conditions and with and without a federal incentive package, either the ITC or the PTC. This results show that the most lucrative financing arrangement includes use of the federal ITC, which is set to expire at the end of 2012. The PTC provides a reasonable rate of return under the higher wind speed scenario, but not as high as the ITC. In the absence of either the ITC or the PTC the IRR is likely too low to attract an investor and the net present value (NPV) of the project is severely negative under these assumptions. Even though extension of the ITC seems less likely than extension of the PTC, it is modeled here to demonstrate the different rates of return made possible by that incentive.

This analysis results in a nominal LCOE of 8.38 cents/kWh ($84/MWh), which is in the range of other estimates for onshore wind development (Table 22).

Table 222. Wind facility SAM results – key financial variables.

With Wind Speed of 7.3 m/s (Capacity Factor of 29.3%)				
Federal Tax Incentive	Annual MWh	Internal Rate of Return	Net Present Value	Project Tax Credits
ITC of 30%	20,532	10.44%	-$172,361	$5 million in Yr 1
PTC of 2.2 cents/kWh	20,532	8.63%	-$1.22 million	$433,000 to $512,000 per year
None	20,532	4.61%	-$3.97 million	$0
With Wind Speed of 7.7 m/s (Capacity Factor of 31.9%)				
Federal Tax Incentive	Annual MWh	Internal Rate of Return	Net Present Value	Project Tax Credits
ITC of 30%	22,234	12.39%	$546,569	$5 million in Yr 1
PTC of 2.2 cents/kWh	22,234	10.42%	-$260,934	$472,000 to $557,000 per year
None	22,234	5.77%	-$3.25 million	$0

Employment Impact

The primary direct economic impacts associated with a wind facility would be seen during the construction phase. The area would not receive any impact from manufacturing the turbines. The majority of the construction impact would be from installation labor and support services as well as wholesale trade. During the operating phase the facilities would require only one full-time person, or less. These estimated impacts are described below and are based on the JEDI model (National Renewable Energy Laboratory, 2011b).

- Construction phase: 16 direct construction jobs + 22 indirect support jobs + 9 induced jobs for a total of 47 temporary jobs.
- Operating phase: 2 full-time jobs, including indirect effects

Non-Market Impacts

While the direct economic impacts of the facility to Grant County will be small following construction, there may be additional benefits to the community that are difficult to measure. These include productive use of marginal land that would otherwise be unused and maintenance of that land for future uses. The community is already familiar with wind facilities, given the presence of two other utility-scale plants in the area. Emissions benefits from displacing fossil-fuel fired generation are also

likely to exist, but these will occur at an uncertain level and, due to the regional nature of power plant emissions, with benefits that may or may not be felt in the project area.

Wind energy does displace conventional fossil-fired generation, but it is uncertain how much emissions will be avoided as the fuel displacement is not always one to one. Presently there is no standard in place that can be used to estimate the emissions avoided by use of variable resources, such as wind and solar, to produce electricity. It has been argued that the effect of an input of electricity from a renewable generator, such as wind or solar, on other generators such as coal or natural gas is difficult to quantify (Federal Trade Commission, 2012).

Comprehensive Land Use Master Plan

Integrating all of the previously described information and defining areas for specific land uses within the Indian Ridge Industrial Park was the next step in the planning process. As discussed in the "Community Engagement, Education, and Training" sections of this report, beginning on page 51, guidance in land uses that are needed within the region are industrial, commercial, recreational and residential. Alternative energy suitability modeling allows researchers to site these facilities in the most appropriate locations.

The Comprehensive Land Use Master Plan for the Indian Ridge site attempts to satisfy the community needs for developable land and provide for spaces to integrate alternative energy generating facilities; that is a SEP. The topography of the existing stormwater infrastructure creates limitations in siting facilities. Other primary limiting factors are the planned expressway corridors. High volume roads require a buffer. Leaving these areas open for future road construction by planting switchgrass in the corridor allows for transitioning the area at a later date. Industrial uses are placed adjacent to the main highway interchange, while residential development is proposed in the south and east of the site. Locating residential development here provides for a sense of seclusion from the highway. Solar infrastructure is located close to FCI-McDowell so that the facility may take advantage of energy production. This location, with its full southern exposure will also be most efficient in solar collection. Commercial development is included in an 'Interchange' zone, providing needed services that were identified as desirable by participants. Areas of switchgrass are planted in areas that are considered marginal, or lacking the spatial requirements of other land uses or in close proximity to areas of sensory disturbance, i.e. highways and industrial development. While the Land Use Master Plan shows segregated land uses, the next level of planning and design proposes integration of land uses. The integration of alternative energy elements (wind, solar, and biomass) will be interwoven with necessary infrastructure and building prototype design. Green infrastructure design of stormwater systems is also an interwoven pattern in the Master Plan (Figure 58).

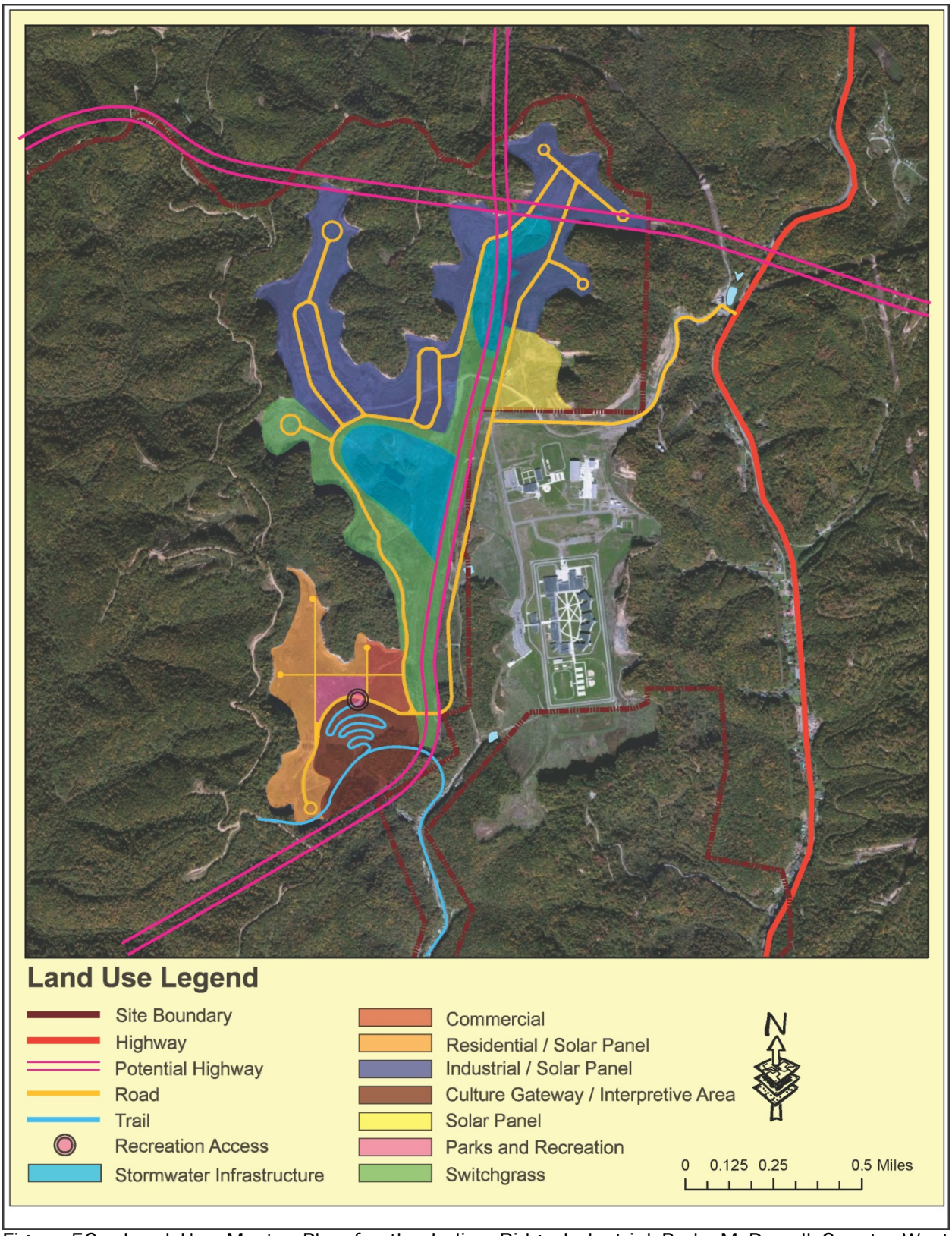


Figure 56. Land Use Master Plan for the Indian Ridge Industrial Park, McDowell County, West Virginia.

Most significant in Figure 59 are the permit boundaries for future surface mining to the south of the Indian Ridge Industrial Park site along the ridgeline. By envisioning this area as a potential SEP, specifically with wind integrated with switchgrass production, a new connectivity is created. The wind turbine polyline shown on the map identifies ridge tops that are connected with existing roadways. These areas are also outside the two kilometer buffer so noise impacts would be reduced for residents of north Welch. The areas of forest within the property boundary that do not have a designated land use will be programmed in more detail in following phases. Input from local officials indicates that recreation land is a potential use of this area and is an identified need in the community. Access to this large recreation area from Welch will take advantage of existing roadways to connect to north Welch.

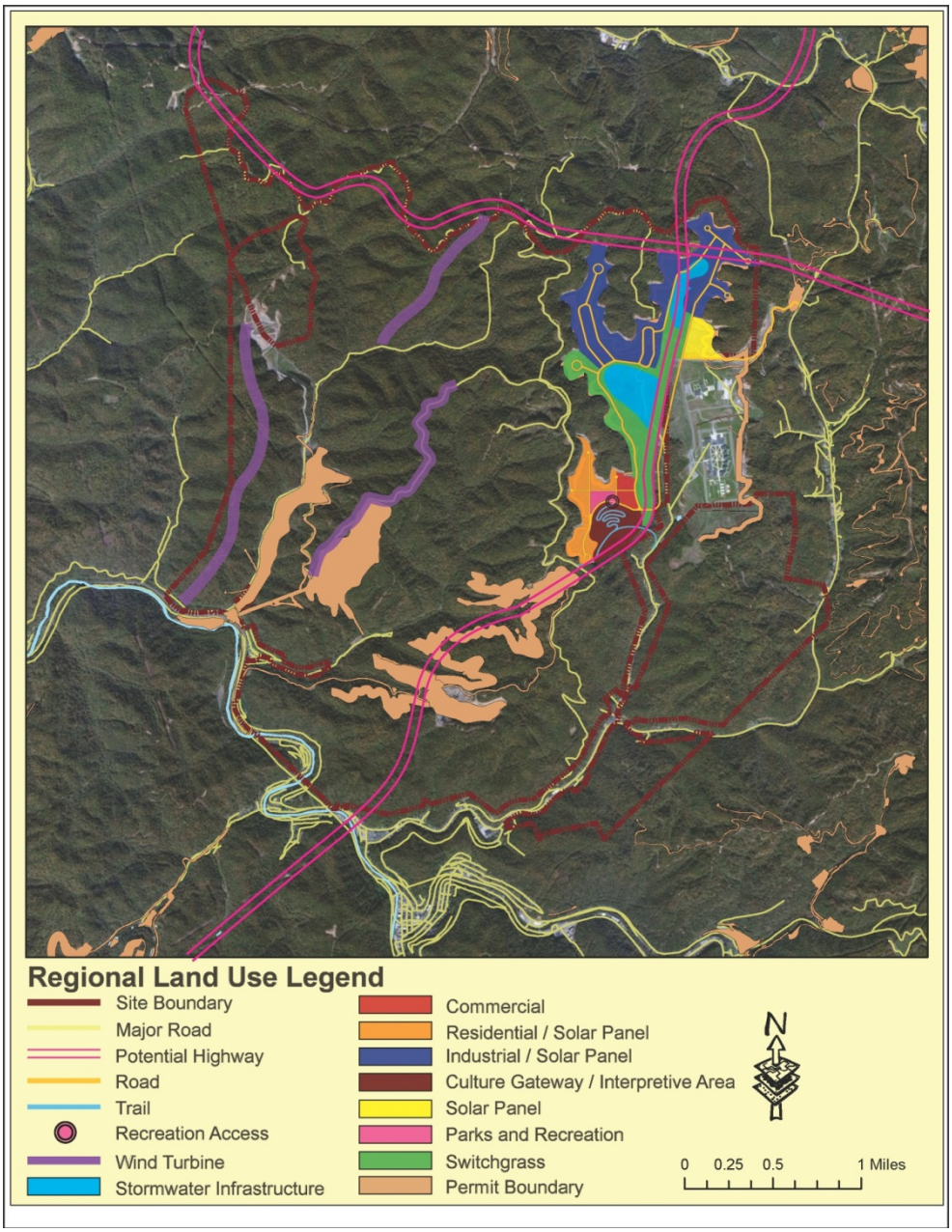


Figure 57. Regional Land Use Master Plan shows the entire Indian Ridge site owned by McDowell County EDA.

Development Phasing

Phasing development of the Indian Ridge Industrial Site allows for a visionary marketing effort with designated areas of future development. The 'Interchange Zone' would not be a suitable land use until the expressways are constructed; however, using that land temporarily in producing biomass through switchgrass planting creates a placeholder for change. Additionally, lands designated for residential/commercial development and industrial development can support switchgrass production while waiting for investment. Solar infrastructure would necessarily be permanent, however, so designating the area adjacent to FCI-McDowell as a future 'new energy' gateway element into the industrial park would create a sense of character for the overall site and define a powerful entry experience (Figure 60).

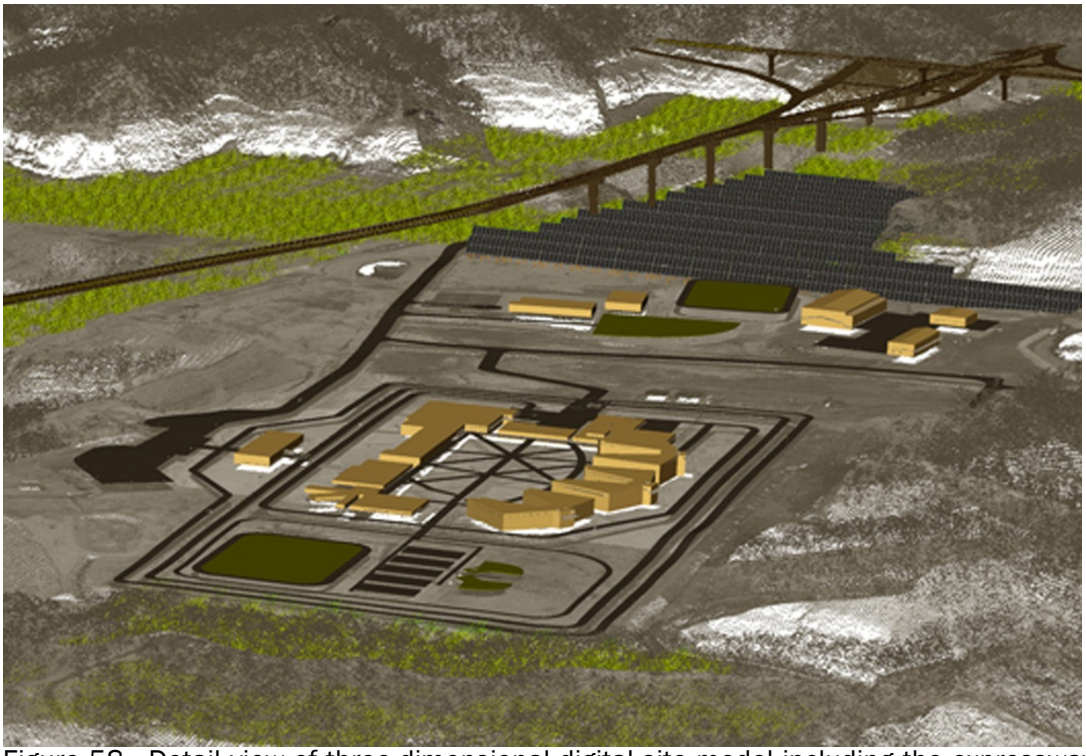


Figure 58. Detail view of three-dimensional digital site model including the expressways, integrated switchgrass and solar facilities (view from southeast with FCI-McDowell in the foreground).

The full Comprehensive Land Use Master Plan with phasing and other considerations being evaluated for implementation by the landowner/McDowell County Economic Development Authority is attached as Appendix N.

Chapter 9 -Conclusions

The Sustainable Energy Park (SEP) project has demonstrated how mine-scarred lands may be redeveloped and reused in an environmentally and economically sustainable fashion through the completion of a Comprehensive Development Plan for the Pilot SEP Site in McDowell County, West Virginia.

Reusing mine-scarred land to produce a variety of sustainable energy sources is achievable in Appalachia from a technical, environmental, and social perspective. The financial return on an investment in SEPs on former surface mine lands is still highly dependent on variables outside the scope of this project.

The ability for SEPs to thrive will be significantly impacted by State Renewable Energy standards, policies, and incentives. The presence of a potential purchaser (a large state/federal or private facility) in close proximity to the energy produced on the SEP will enhance the viability of the SEP. Initially, the SEP was conceived to produce utility scale power; however, the presence of a "local" end user would reduce the cost of necessary infrastructure

Due to the characteristics of the mine soils in West Virginia, switchgrass biomass yields will be approximately 4 to 8 tons per acre, depending on species and amendments. Other biomass species, such as Miscanthus and Arundo, can yield tonnage rates as high as 12 tons per acre. These biofuels, when harvested and baled into 1 ton bales, typically mimic hay prices which vary from $50 to $100 per ton. It should be of note that these prices often fluctuate from season to season depending on supply and demand for the product.

Some of these biomass bales end up becoming used as feedstock for the pelletizing industry. The processed pellets can often yield approximately $125.00 per ton. However, at this time, the market is not conducive for selling this product.

The McDowell county site, located in southern West Virginia, has approximately 224 acres that are suitable for the development of biomass crops. This site, once planted and harvested, could produce approximately 1,344 tons per year of biofuel. This fuel could then be sold on the market where it could net approximately $80,000 per year based on 2012 rates. Planting and maintenance costs would impact this number. The biofuel could be used as a fuel source to power the boilers at the nearby federal prison or could be used for pelletizing.

The selected Indian Ridge project site in McDowell County is a former surface mining area. It met the site characteristics and screening criteria for available land, distance to transmission lines, and distance to roads. However, the wind resource potential, at 4.6 m/s at 80m, was too low for the site to be viable for wind energy for medium- to high-speed turbines. A wind speed of at least 5.5 m/s at 80m turbine height must be present for a property to be considered for medium- to high-speed turbines. The site may still be considered a candidate dependent on the availability of turbines capable of utilizing low-speed wind and additional research on viability.

If interest exists, the wind resource potential could be measured by an anemometer to obtain a more site-specific measurement of the wind speed, which will determine if the wind resource potential is above or below the required 5.5m/s at 80m wind speed.

The McDowell County site fares well when evaluated against EPA's Re-Powering America's Land Initiative's pre-screening site characteristics. The site receives more than 3.5 kwh/$M^{2/day}$ of solar insolation and much of the acreage is located less than one mile from a graded road. The site also fares well with other screening characteristics such as load assessment. However, the site does not

fare well with regards to financial screening due to the lack of utility or other state-based incentives for PV. Based on this research and the Prioritization Tool developed, of our 612 sites, we determined that 109 sites had potential for biofuels development, 4 sites had potential for solar development, and 1 site had the potential for wind development.

Lessons Learned

The concept of utilizing mine-scarred lands in Appalachia for sustainable energy production is a valuable area of research due to the proximity of the sites to a large portion of the country's energy demand from major metropolitan areas on the east coast. As McDowell County pursues the adoption of the Comprehensive Land Use Master Plan, reflections on future projects is in order.

Lesson 1: The definition and use of the term Mine-scarred land is significant

From a regulatory basis, multiple federal and state agencies oversee coal mining. The Office of Surface Mining and other agencies do not have an equivalent term to mine-scarred lands, but rather specific delineations between mines based on the Surface Mining Control and Reclamation Act (SMCRA). The ability for a SEP to take shape is also impacted by the status of a mine permit, and the status of bond release. Coordinating the definition of the term mine-scarred land with other agencies is critical to discussing and generating buy-in from industry, regulatory officials, and landowners. The definition also impacts site identification.

Coalfield communities created around the coal mining industry are sensitive to the term mine-scarred lands. During our outreach and community engagement we learned the public is interested in exploring sustainable energy production, but do not want their history of coal mining to be disparaged. The legacy and psychological connection to coal miners is substantial in the Appalachian Coalfields. Coal mining has been recognized as a significant part America's cultural, labor, and industrial heritage including the current development of a cottage tourism industry surrounding mining. Mine-scarred lands have a negative connotation. Consider using different terminology to build relationships versus an antagonist relationship with local communities.

Lesson 2: Stakeholder Engagement is Critical

Community engagement in the development of a land use master plan that encompasses the energy production pieces plus other community priorities will result in a more robust and supported Comprehensive Land Use Master Plan than limiting land use considerations to SEPs only.

Lesson 3: Land Ownership/Control Considerations

Site control and land ownership considerations are a driving factor in the ability to access the property for placement of alternative technologies. Appalachia has many large (> 100 acres) former mine sites that appear to be idle or abandoned. Mining leases, the permitting process, and other land ownership considerations are complex. Investors and developers not familiar with the mining industry will be at a disadvantage to capitalize on the unique mining regulatory framework compared to other non-mining properties.

Lesson 4: Think Local Energy End Users

The initial focus of the SEP model was to produce utility scale energy on mine-scarred lands. Identifying local institutional energy uses may result in a larger local economic benefit, increased environmental benefits, and support more local energy independence. Buy-in from multiple local users might result in more alternative energy initiatives and production than fewer large-scale users. Some of the enhanced environmental benefits from partnering with a local institution which would serve as the potential energy end user includes:

- Reduction in costs due to the elimination of constructing unnecessary energy infrastructure
- Increase in energy efficiency by reducing distance energy travels and reducing associated energy loss.

The Research Team worked with Federal Correction Institution (FCI) McDowell as a potential energy end user. Federal facilities and other large state, and private institutions have incentives to utilize sustainable energy that may not exist for other local small-scale energy end users.

The use of energy by a specific local end user also eliminates some of the regulatory and infrastructure barriers associated with converting the energy to utility scale.

Results Summary

This project provides the framework to target the key information needed to identify potential sustainable energy sites and catalyze a companion "green" energy industry to coal in Appalachia. Using a database of over 15,000 former surface mines in West Virginia, researchers identified 612 candidate sites which meet the threshold criteria for SEPs. The **Portfolio of Candidate Sustainable Energy Park Sites in West Virginia** is provided in Appendix 4. The same research method and technical criteria used to select candidate sites could be applied in other Appalachian states to identify SEP opportunities.

A **Prioritization Tool and Handbook** were created to assist community leaders and economic development officials optimize their limited resources through the identification of the highest potential SEP sites in their area. Important aspects of the Tool and Handbook are the learning and local capacity building that occurs during the data collection and analysis. The process provides an avenue for collaboration and information sharing that will result in broader understanding of sustainable energy technologies and opportunities that may have otherwise been overlooked. The utilization of the tool also illustrates to investors that a certain level of community interest and capacity exists for the development of a SEP.

The **selection of a Sustainable Energy Park Pilot Site** was a crucial element in determining the feasibility of the SEP concept. Through a Request for Proposals process, coalfield communities competed for the opportunity to serve as the pilot site. This competition illustrated interest and local official buy-in.

The **creation of a Comprehensive Development Plan** was completed through extensive coordination and engagement with the McDowell County Economic Development Authority and local stakeholders. The Comprehensive Development Plan includes a Land Use Master Plan for the site that is under consideration for adoption by the McDowell County EDA Board of Directors. The plan has already yielded significant interest from the adjacent landowner, FCI-McDowell. The partnership with FCI-McDowell is significant due to their role as a stakeholder in the stormwater management of the site, and as a potential end-user of the energy produced by solar, wind, or biomass harvested on the pilot site. The education and outreach that has occurred with FCI-McDowell officials may also result in a partnership to plant biomass on the FCI property. A decision to plant biomass on suitable FCI property would increase the overall acreage available for biomass planting at the SEP site. This increased acreage will result in a higher yield of the biomass feedstock and positively impact the economic feasibility of the project.

Showcasing the Sustainable Energy Park Project and Pilot Site was a key component to attracting interest and investment in the concept of reusing mine sites for alternative energy production. The showcasing strategy included hosting activities as well as participating in other energy-related conferences to display the project's concepts, results, and potential.

Leveraged Funding

The West Virginia Water Research Institute's Northern West Virginia Brownfields Assistance Center leveraged $50,000 from the West Virginia Division of Energy to incorporate brownfields and concepts of sustainability into the state-required land use master planning process for counties with mine-scarred lands. This will have a long-term impact on how coalfield communities in West Virginia plan for the reuse of former surface mine sites.

Project researchers were also able to leverage a total of approximately $687,000 worth of technical data related to biomass production on mined lands. Team researchers identified suitable varieties of biofuel crops at several sites across the state and identified the required agronomic inputs and economic returns. Specifically, team researchers are evaluating evaluated biomass production per acre, carbon sequestration via root turnover and soil organic matter accumulation and the cost of producing a ton of dry plant material. The leveraged costs include site preparation, planting, fertilization, management and harvesting. Researchers evaluated the economics of cellulosic ethanol production technology and pelletizing switchgrass for institutional power generation and heating uses. This project, *Switchgrass Demonstration Planting on Mine Land,* with a total value of $687,027.35 is anticipated to continue through 2016.

In addition, the West Virginia Division of Energy has committed approximately $40,000 to complete a spring 2013 biomass planting in coordination with the FCI - McDowell as a result of the USEPA funded Sustainable Energy Park Project.

Future of the Project

With additional SEP research funding, the selection and analysis of an additional pilot site in another Appalachian state with different sustainable energy production incentives would further evaluate the feasibility of SEPs on mine-scarred lands over the entire Appalachian region. This additional research also has the potential to impact future energy policy decisions on a statewide basis, with regional and national environmental implications.

Appendices

Appendix A – Soil Sample Results
Appendix B – Data Source Methodology
Appendix C – Indicators and Data Sources
Appendix D – Portfolio of Candidate Sites
Appendix E – Prioritization Tool and Handbook
Appendix F – SEP Fact Sheet
Appendix G – Project Flyer
Appendix H – Request for Proposals
Appendix I – Visualization Presentation
Appendix J – Feedback Loop Exercise
Appendix K – Community Meeting Presentation
Appendix L – Comprehensive Report on Biofuels
Appendix M – SEP Showcase Video
Appendix N – Comprehensive Land Use Master Plan

References

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