Renewable Energy Research and Demonstration Projects on Surface Mine Lands

Renewable Energy in West Virginia: Projects and Prospects in 2016

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PRESENTED BY MARSHALL UNIVERSITY CENTER FOR ENVIRONMENTAL, GEOTECHNICAL AND APPLIED SCIENCES (SUPPORT FROM THE WEST VIRGINIA BROWNFIELDS ASSISTANCE CENTER AT MARSHALL UNIVERSITY)

Project Funding Details

Appalachian Regional Commission, West Virginia Division of Energy, and Matching Grant Cost Share
Total ~$1.3 million since 2010

Three Main Initiatives:

1. Surface Mine Land Property Evaluations for New Use
-Performed in conjunction with the WV Brownfields Assistance Center at Marshall University

2. Wind Energy Resource Studies on Surface Mine Land Properties
-conducted by Marshall University's Center for Environmental, Geotechnical, and Applied Sciences (CEGAS), with assistance from Marshall University's Center for Business and Economic Research

3. **Renewable Energy (and Agriculture) Sub-grants on Surface Mine Land Properties**
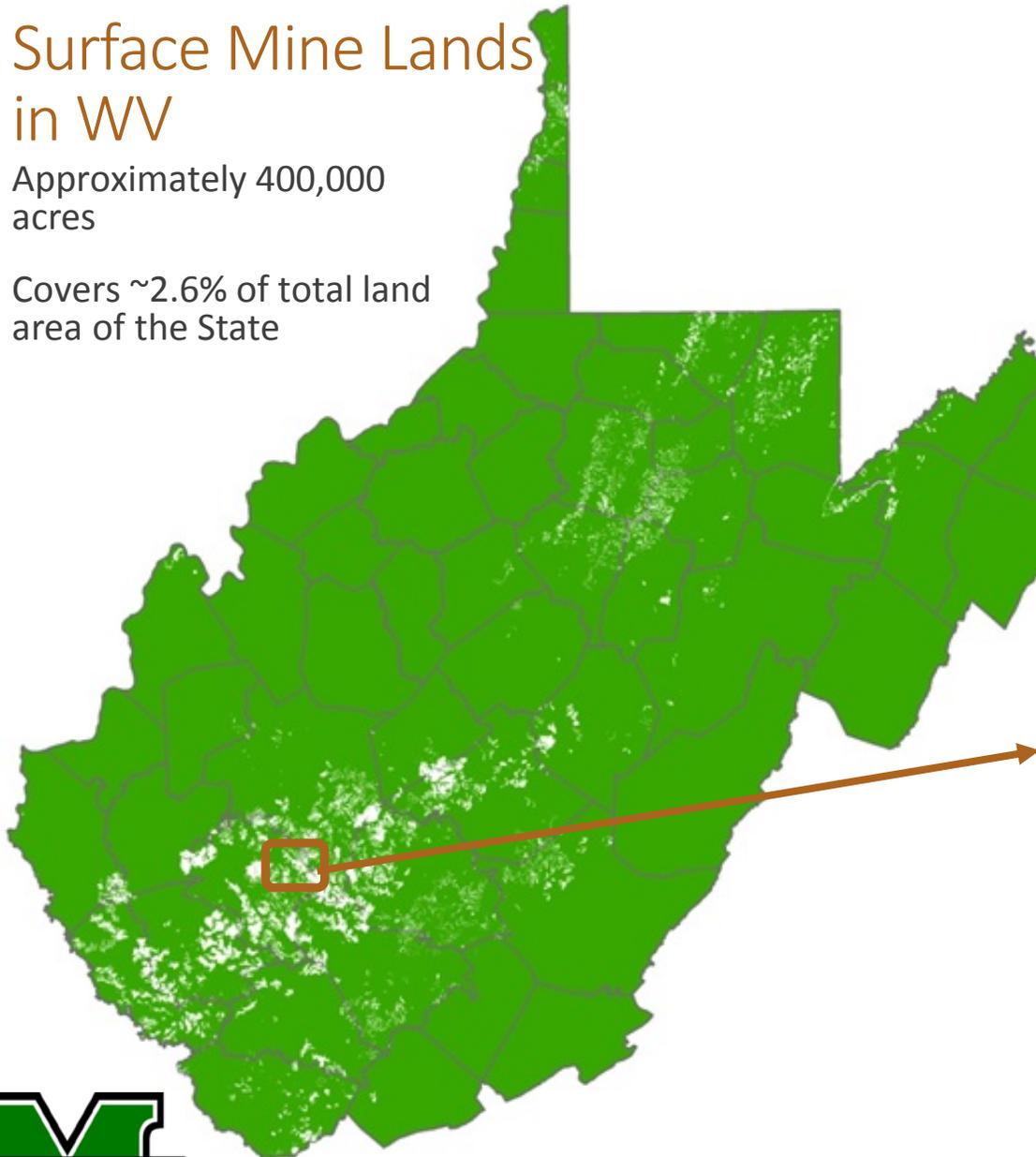-Projects administered by CEGAS, in conjunction with the WV Brownfields Assistance Center at Marshall University
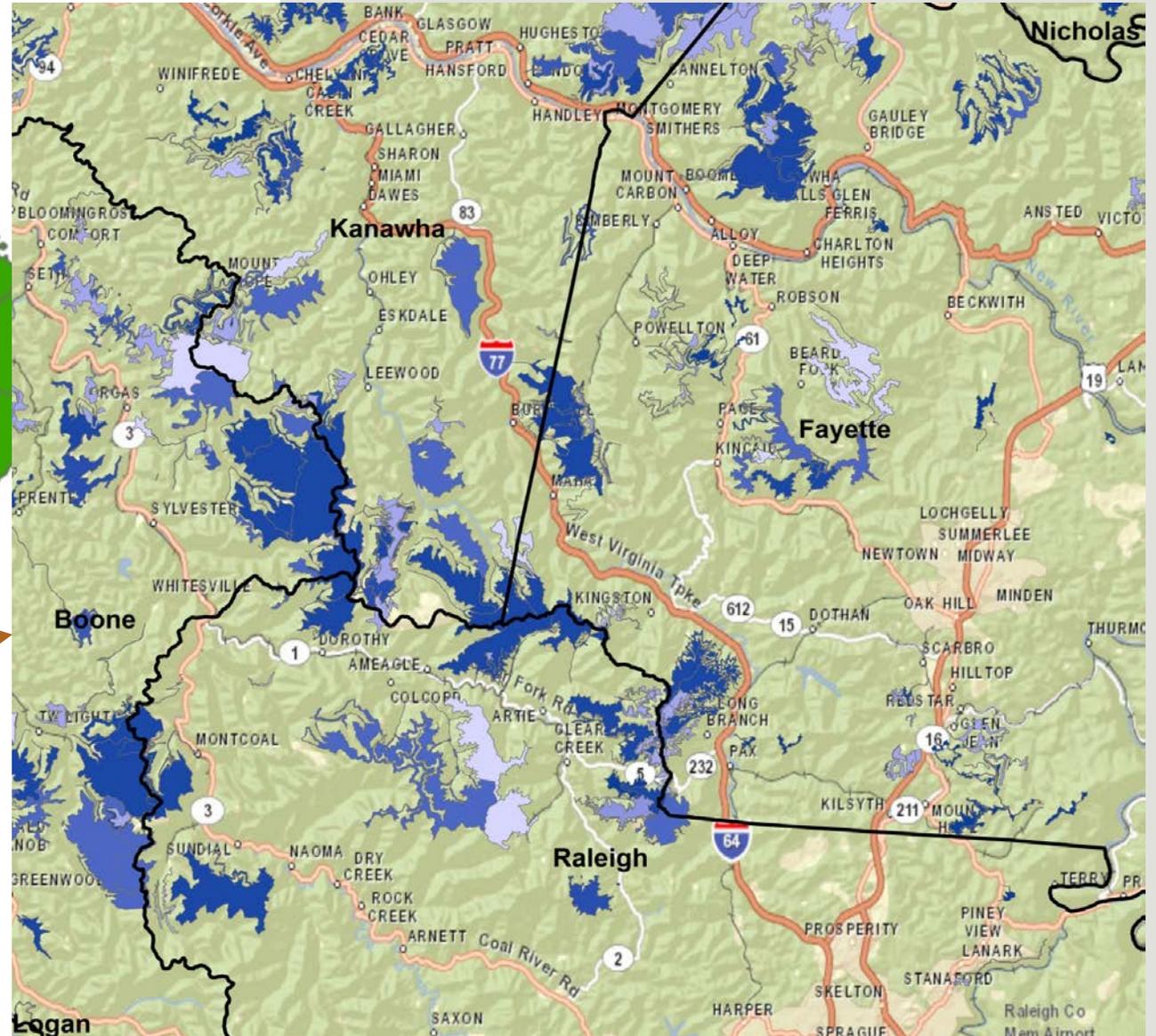
Surface Mine Lands in WV

Approximately 400,000 acres

Covers ~2.6% of total land area of the State

Blue Shades = Surface Mine Lands
(from WVDEP mining databases)

Initiative 1

Surface Mine Land Property Evaluations for New Use

Some surface mine lands have infrastructure components that could be utilized for new use.

Based on specific site features, new business, industry, housing, agriculture and/or recreational opportunities may exist.

Sites are reviewed based on location, infrastructure, land owner interests, reclamation status, associated deep mine water pools (if present), and associated positive features

Property marketing packages are compiled for use by the land owner(s), WV Division of Energy, WV Brownfields Assistance Center, and/or local EDA's (7 packages compiled to date; others pending)

Initiative 2
## *Wind Energy Resource Studies on Surface Mine Lands*

Sonic Detection and Ranging (SODAR) Equipment used for data collection (data retrieved via satellite, solar panels and deep cycle batteries used for power supply)

Locations identified for evaluation based on elevation, available modeled wind data (AWS Truepower™), surface mine site conditions, and landowner interest/participation

7 locations analyzed for wind energy production potential; 1 correlation study between SODAR and met. tower (last site just concluded – report being finalized); reports on WVDOE website

✦ Study Location
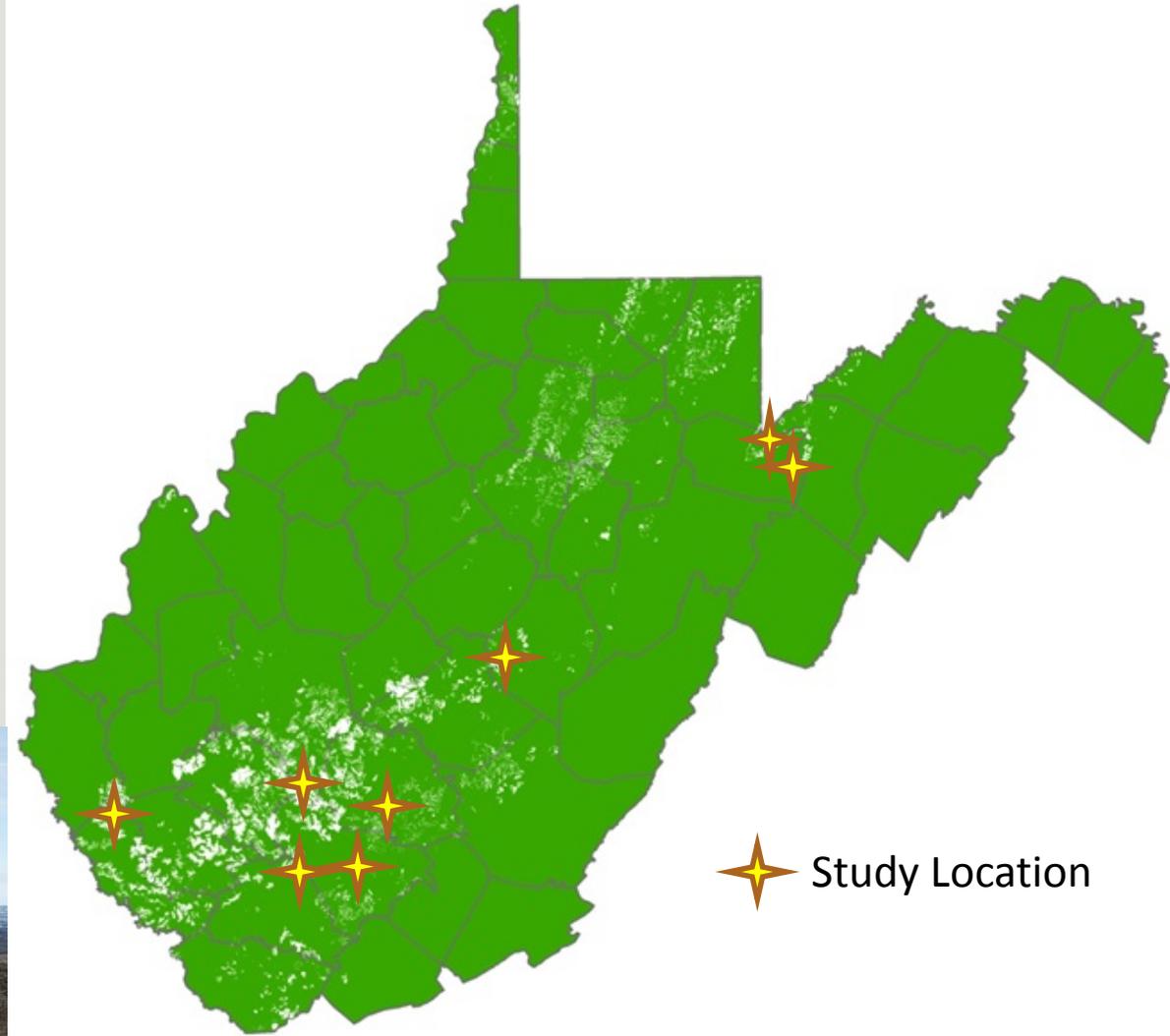
Sonic Detection and Ranging (SODAR)
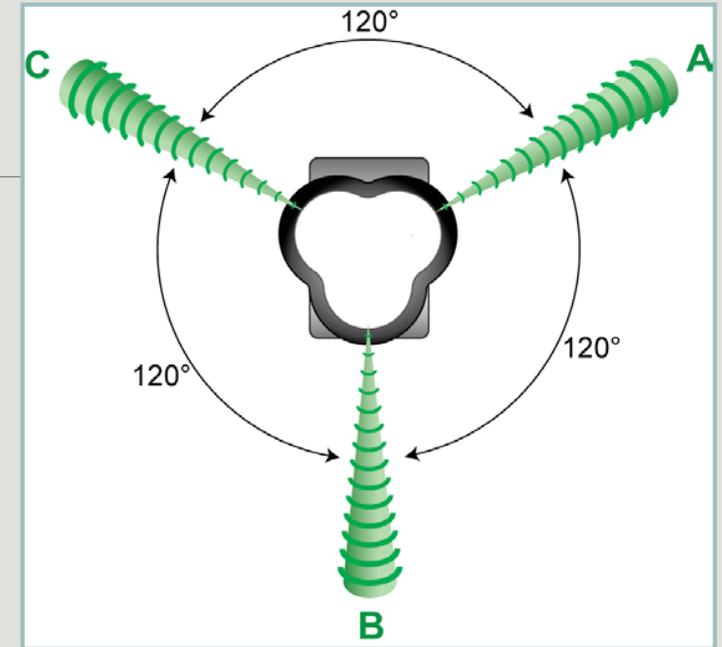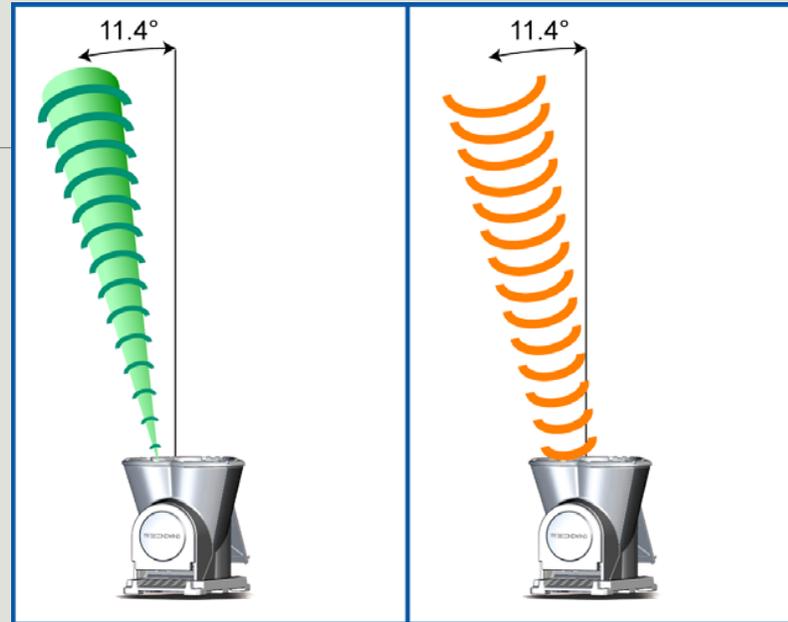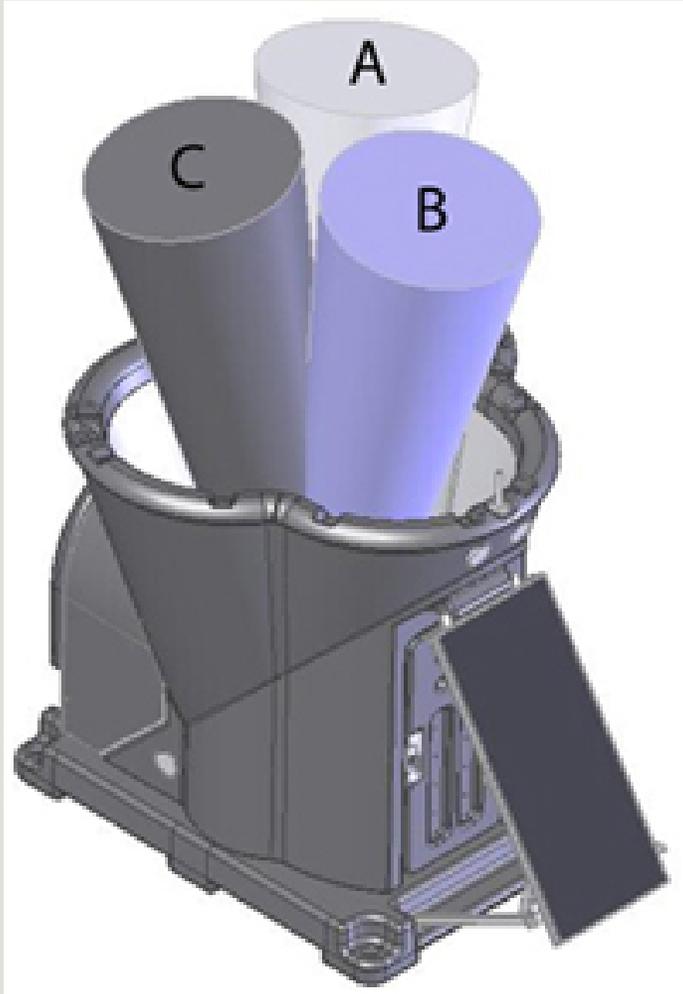
SODAR Transmits high frequency acoustic pulses and measures how they scatter and return. Sources of scattering are irregularities in wind velocities, air temperature and density, causing acoustic refractive index changes. By measuring the Doppler shifted frequency of the returned signal, wind speed and direction at various altitudes are determined.

SODAR measures wind speed, wind direction and other atmospheric conditions from 40 to ~200 meters above the ground surface, at 4 to 5 second intervals.

Collected data is loaded into *Windographer*™ software for analysis, using small, medium and large-scale wind turbines for potential energy output determinations.

Measures Full Rotor Sweep

At 120 meters: 100% Direct Data
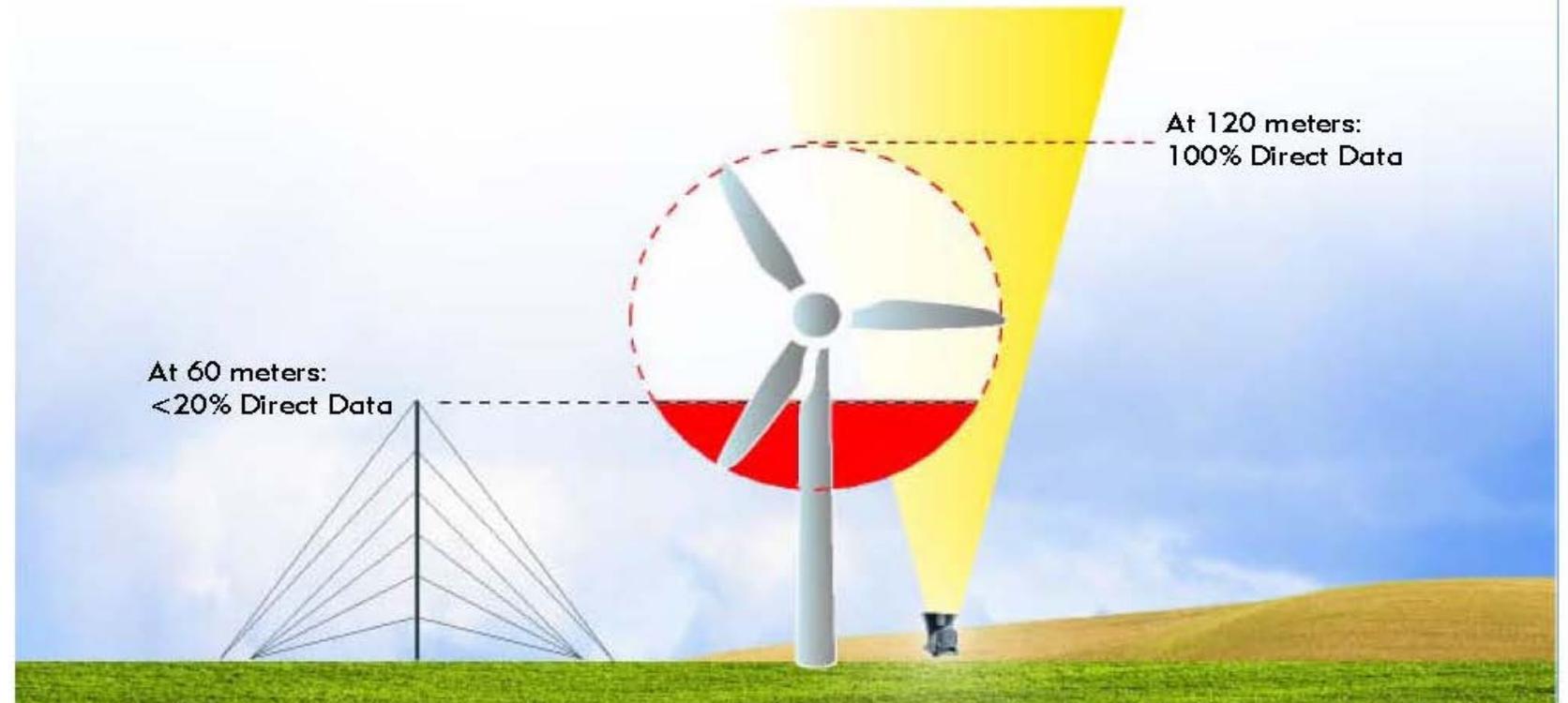
At 60 meters: <20% Direct Data

*Towers >60 meters require FAA permitting

SECONDWIND

Example Wind Turbine Outputs

Left Window — GE 2.5xl

Wind Turbine Output

This window calculates the energy output of a wind turbine in this wind regime. Select a type of wind turbine and a hub height, then click Calculate Output.

Wind turbine: GE 2.5xl — Details... Edit... New... Delete... Compare...

Properties
- Manufacturer: GE Wind
- Website: www.gepower.com
- Rotor diameter: 100 m
- Rated power: 2,500 kW
- Power regulation: Pitch control

Hub height
- ( ) 75 m (selected)
- ( ) 85 m
- ( ) 100 m
- ( ) Other   70 m

Losses
- Downtime losses (%): 6
- Array losses (%): 5
- Icing/soiling losses (%): 4
- Other losses (%): 4
- Overall loss factor (%): 17.70

Calculate Output

( ) Monthly details   ( ) Turbine comparison

Month	Valid Data Points	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (kW)	Mean Net Energy Output (kWh/yr)	Net Capacity Factor (%)
Jan	4,462	7.03	9.48	4.86	607.5	451,975	24.3
Feb	4,176	6.76	13.36	5.48	636.8	427,941	25.5
Mar	4,137	5.94	12.98	0.12	429.3	319,413	17.2
Apr	4,318	6.53	10.24	1.69	556.3	400,536	22.3
May	4,461	4.76	21.95	0.00	210.5	156,606	8.4
Jun	4,317	4.67	27.89	0.00	219.1	157,728	8.8
Jul	4,459	4.04	33.86	0.00	121.2	90,199	4.8
Aug	4,463	4.59	23.59	0.40	189.7	141,131	7.6
Sep	4,317	5.62	15.75	0.21	380.6	274,007	15.2
Oct	4,462	5.62	19.03	2.87	385.3	286,656	15.4
Nov	4,318	6.72	14.61	2.55	649.8	467,828	26.0
Dec	4,464	6.65	13.24	1.90	619.5	460,914	24.8
Overall	52,354	5.74	18.06	1.67	415.5	3,639,793	16.6

Help   Cancel   Add Turbine Output Time Series To Data Set & Close

Right Window — Endurance G-3120

Wind Turbine Output

This window calculates the energy output of a wind turbine in this wind regime. Select a type of wind turbine and a hub height, then click Calculate Output.

Wind turbine: Endurance G-3120 — Details... Edit... New... Delete... Compare...

Properties
- Manufacturer: Endurance Wind Power
- Website: www.endurancewindpower.c
- Rotor diameter: 19.2 m
- Rated power: 35 kW
- Power regulation: Stall control

Hub height
- ( ) 30.5 m
- ( ) 42.7 m (selected)
- ( ) Other   70 m

Losses
- Downtime losses (%): 6
- Array losses (%): 5
- Icing/soiling losses (%): 4
- Other losses (%): 4
- Overall loss factor (%): 17.70

Calculate Output

( ) Monthly details   ( ) Turbine comparison

Month	Valid Data Points	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (kW)	Mean Net Energy Output (kWh/yr)	Net Capacity Factor (%)
Jan	4,462	5.74	19.54	0.09	9.6	7,133	27.4
Feb	4,176	5.75	24.50	0.12	10.3	6,949	29.5
Mar	4,137	5.01	21.54	0.00	8.0	5,915	22.7
Apr	4,318	5.68	18.39	0.00	10.1	7,242	28.7
May	4,461	4.11	31.54	0.00	4.8	3,553	13.6
Jun	4,317	3.93	38.55	0.00	4.5	3,216	12.8
Jul	4,459	3.30	47.32	0.00	2.3	1,678	6.4
Aug	4,463	3.36	46.85	0.00	2.3	1,687	6.5
Sep	4,317	4.40	33.12	0.00	5.8	4,179	16.6
Oct	4,462	4.60	32.72	0.00	6.4	4,797	18.4
Nov	4,318	5.86	25.36	0.00	10.9	7,866	31.2
Dec	4,464	5.71	21.62	0.00	10.5	7,834	30.1
Overall	52,354	4.78	30.18	0.02	7.1	62,085	20.2

Help   Cancel   Add Turbine Output Time Series To Data Set & Close

Cotiga Property
Mingo County

Arch Coal Surface Mine
Webster County

Boy Scout – Bechtel Summit Property
Fayette County

Results

➢ SODAR and met tower study resulted in >98% correlation
➢ Grant County sites have excellent wind resource potential
➢ Webster, Kanawha, Raleigh, Fayette sites are marginal for commercial development, better for smaller-scale turbines
➢ Could have future potential based on new technology developments (greater efficiency ratings, new blade designs, higher hub heights, etc.)
➢ Mingo and Wyoming sites have generally poor wind resource potential

Initiative 3

Renewable Energy (and Agriculture) Sub-Grants on Surface Mine Land Properties

Projects had to be located on former or current surface mine land in West Virginia

14 projects total since 2010
-Demonstration projects include solar, micro-hydro, tree/grass biomass-biofuel, agriculture, and combined solar/agriculture

Project Partners (project grantees, landowners, and direct project support):
West Virginia State University, McDowell County EDA, Arch Coal, Randolph County EDA, Appalachian Hardwood Center, Webster County EDA, Plum Creek Timber Company, WVU Research Corporation, McDowell County Schools, Regency Gas / PVR Partners, Monongalia County Schools, Morris Creek Watershed Association, WV Brownfields Assistance Center at Marshall University, Prichard Mining, WV National Guard, Williamson Health and Wellness Center, Mingo County Redevelopment Authority, Central Appalachian Empowerment Zone, Natural Resource Partners, Consolidated Coal, WVDEP-Division of Land Restoration, WV Department of Agriculture, U.S. Department of Agriculture, and multiple private contractors.

Soil ripping prior to tree planting
(Bolair site, Webster County)

Miscanthus planting
(McDowell County EDA property, adjacent
to Federal Correctional Institution)

Planting tree seedlings
Randolph County biomass site

Weed spraying application
around tree seedlings -
Plum Creek biomass site

Awning-Style Solar Panel Array
University High School
(6.0 kW)

Solar arrays for classroom demonstration and education, with real-time system monitoring

Rooftop Solar Panel Array
Mount View High School
(5.28kW)

Acid Mine Drainage Treatment, former Buffalo Coal bond forfeited site, Grant County

System operated by WVDEP

Installing 2.88 kW solar panel array with battery power storage for automation of liming facility; off-grid power use / propane generator backup if needed
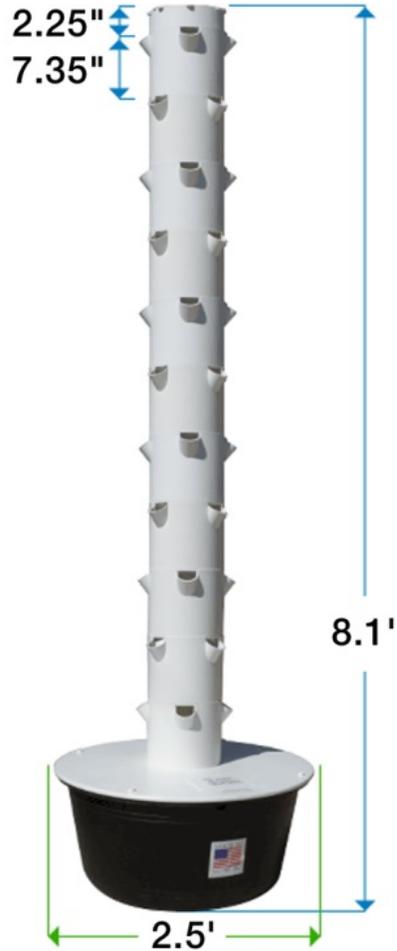
System installation Summer 2016

Micro-hydro turbine
Morris Creek Watershed

2013/02/

2013/03/14

Uses water discharge from former deep mine for power source

1.3kW unit for demonstration and education at the Morris Creek Watershed Association

2.25"
7.35"

8.1'

2.5'

11 Pots — 44 Planting Spaces

WV Turnpike Tunnel site, location of high tunnel with solar panels for aeroponic towers, under direction of WV State University - Extension Service, using deep mine pool water.

ARC / WVDOE funds being used for solar panels and battery bank for off-grid power use (low-flow pumps and lighting)

System Installation May-June 2016

MARSHALL

West Virginia Surface Mines – Future Sites for Agriculture, Recreation, Housing, Industry/Business, and **Renewable Energy**

THANKS