Adaptive reuse of mined lands for solar energy

by Alan A. Campoli, J. Steven Gardner, Douglas K. Mynear, D. Anderson Willis and Seth Mittle

The diversification of energy sources in the United States has seen some major shifts during the past decade resulting from:

- A sudden abundance of low-cost natural gas becoming available through advanced horizontal drilling and hydraulic fracturing techniques.
- Incentive-driven policies leading to new development in alternative energy.
- The emergence of alternative energy sources proliferated as a result of state and federal level incentives and falling capital costs.

Coal was once recognized as the primary low-cost fuel source for the generation of electricity in the United States for most of the last century, providing upward of 50 percent of the total generation capacity during much of that period. However, within the past decade, lower-cost natural gas has overtaken coal as the primary source of fuel used in electricity generation, and alternative sources have steadily grown to now account for approximately 10 percent of the overall mix.

West Virginia and Kentucky have not experienced the full breadth of the fuel shift, and, as of 2016, still obtained approximately 80-90 percent of electric power generation from coal. However, as coal plants are retired, there has been a shift toward natural gas for new power plants constructed in the region. The economics of power generation (i.e., low-cost fuel source) has typically been the major factor in determining shifts from one fuel source or technology to another. However, governmental energy policies and incentives have more recently been used to promote the development of new alternative technologies such as wind and solar energy growth to diversify the energy mix. The implementation of these incentives has provided some needed traction and resulted in driving the cost of manufacturing and installation of these new wind and solar systems downward to be more cost competitive with conventional fossil-fueled power sources. Future shifts in the generation capacity by fuel type will also be inevitable and impossible to project accurately as policies change and innovative technologies evolve. Determining factors may include the expiration of current incentives, decreasing capital costs, future environmental regulations, evolution of energy storage systems, technical challenges associated with increasing intermittent sources of generation and the development of unforeseen technologies. West Virginia and Kentucky have been among the least solar friendly states, ranking 44th and 48th of the 50 states (Fig. 1 for WV). The ranking of other coal producing states are similarly low:

- Ohio 20
- Pennsylvania 21
- Virginia 38
- West Virginia 44
- Wyoming 45
- Kentucky 48
- Alabama 50

Nuclear and hydro generation have remained relatively stable in their share of generation capacity, while alternative energy sources have consumed approximately five percent of the generation capacity previously provided through fossil fuel sources. Within the fossil fuel category, the significant shift from coal to natural gas is strikingly evident. Within the alternative categories, wind and solar represent the fastest current growing fuel sources. These long-term trends are also further illustrated in Fig. 2, provided by the U.S. Energy Information Administration (EIA).

West Virginia and Kentucky, however, have not to date experienced the same rate of growth in solar generating capacity that many other states have witnessed. While recognizing the intensity of solar energy available in West Virginia and Kentucky is considerably less than that experienced in the solar-rich southwestern U.S. region, it is still comparable in intensity to other adjacent states that have seen significant growth in solar implementation, such as North Carolina, Maryland, Virginia, Pennsylvania, Ohio and other regional states. The primary determining factor in this difference appears to be policy-driven, highlighting the lack of incentives toward solar development. West Virginia and Kentucky do not have Alternative Portfolio

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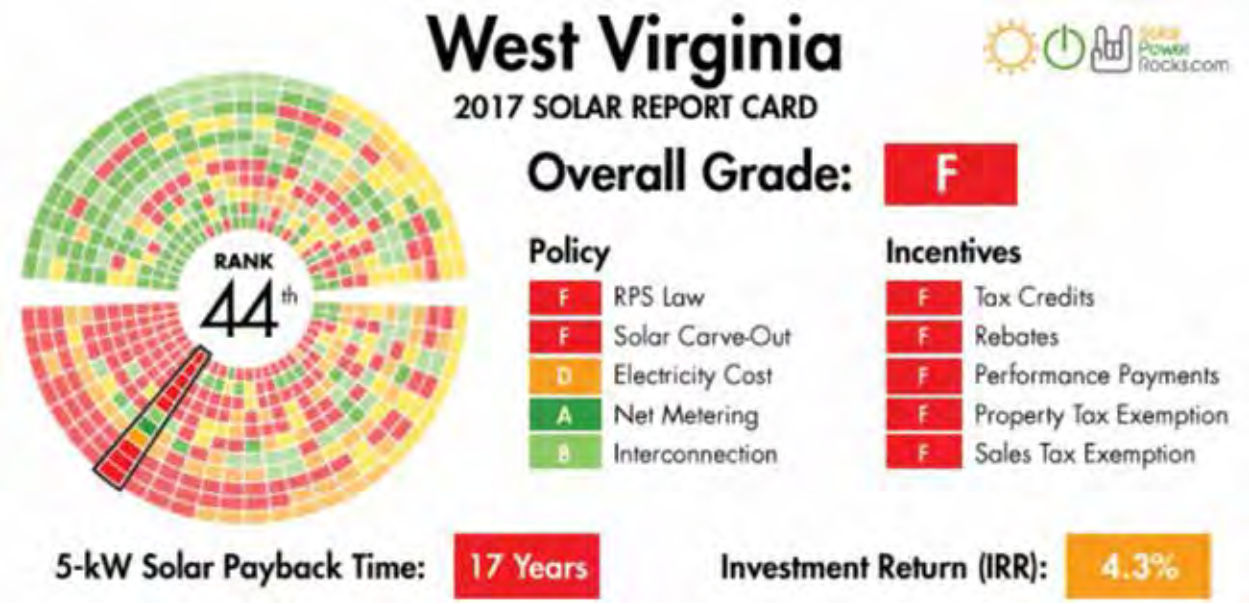
Figure 1

West Virginia solar friendly ranking.



Standards legislation, and both states continue to trail all the other surrounding states in the development of solar generating capacity and jobs growth in the solar industry.

Federal solar policy analysis

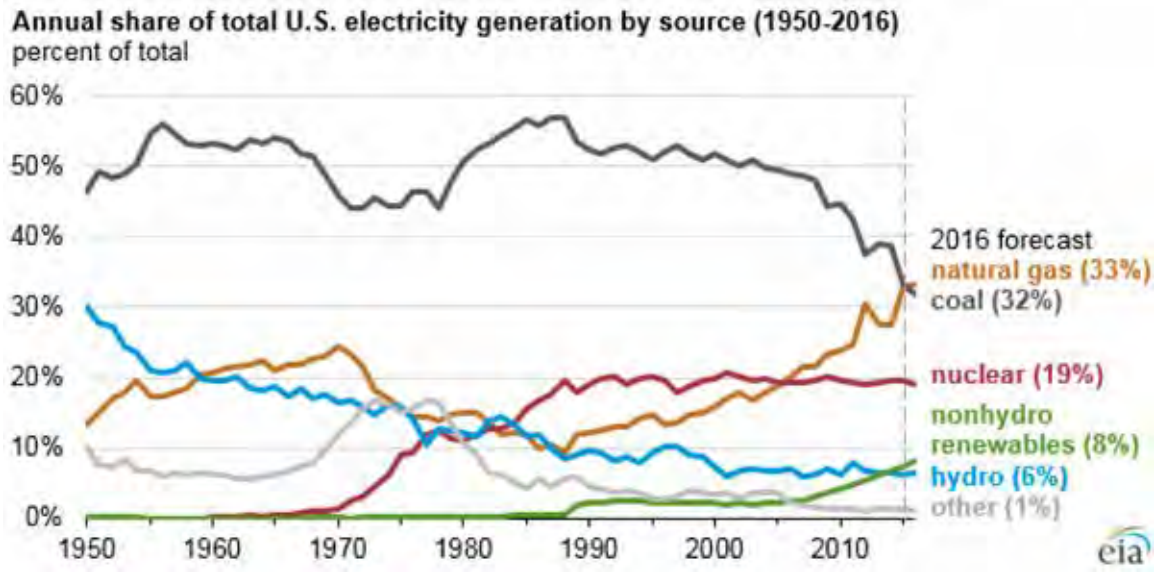
During the past few decades, the federal government has both promoted and then de-emphasized programs and policies to encourage energy conservation and alternative energy sources. These policies have included: tax incentives to encourage installation of solar energy power systems, alternative energy percentage usage goals, and grant and loan programs to help in funding solar energy systems. In 2008, the U.S. Environmental Protection Agency (EPA) launched its "RE-Powering America's Land Initiative," that strives to encourage alternative energy development on current and formerly contaminated lands, landfills and mine sites. During the Obama presidential term (2009-2016), the policies were predominantly favorable for solar energy development, and because of these policies and falling capital costs, there was significant growth in the solar sector of energy production. However, recent actions by the Trump administration through implementation of a 30 percent declining tariff on imported solar panels signed into law in January 2018, cast some doubt on future attitudes toward alternative energy and the short-term continuity of the incentives and loan programs.

Current federal policies, programs and goals include the following:

- Business Energy Investment Tax Credit (ITC) — The Energy Policy Act of 2005 provided for an increase in the Business Energy ITC from 10 percent to 30 percent of the cost of a photovoltaic system to further incentivize investment in solar power production.
- Modified Accelerated Cost-Recovery System — Taxpayers claiming the Business Energy ITC for placing a solar photovoltaic system in service can also typically take advantage of accelerated depreciation rules to further reduce installation costs and attract capital. When the commercial ITC is claimed, accelerated depreciation rules allow for 85 percent of the tax basis of the installation to be depreciated over a five-year period. Equipment placed in service before Jan. 1, 2018 can qualify for 50 percent bonus depreciation.
- Green power purchasing goal for federal government — The Energy Policy Act of 2005 expanded several previous goals and standards to reduce federal energy use in buildings. Under the order and where the installation is life-cycle cost-effective, the percentage of energy for federal buildings supplied by alternative sources shall be 30 percent in fiscal year 2025 and thereafter.
- U.S. Department of Energy Loan guarantee program — Earmarked for projects with high technology risks that "avoid, reduce or sequester air

Figure 2

U.S. electrical energy generation by fuel source.



pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued."

- Clean alternative energy bonds (CREBs) — Designed for use by primarily public-sector entities to finance alternative energy project. CREBs may be issued by electric cooperatives. The bondholder receives federal tax credits in lieu of a portion of the traditional bond interest, resulting in a lower effective interest rate for the borrower.
- Public Utility Regulatory Policies Act (PURPA) of 1978 — Was part of the National Energy Act designed to promote energy conservation and to encourage the development of alternative energy generation. It created a market for nonutility power producers by requiring utilities to purchase power from eligible power producers as long as the cost of the electricity was below the utility's avoided cost.

West Virginia solar policy analysis example

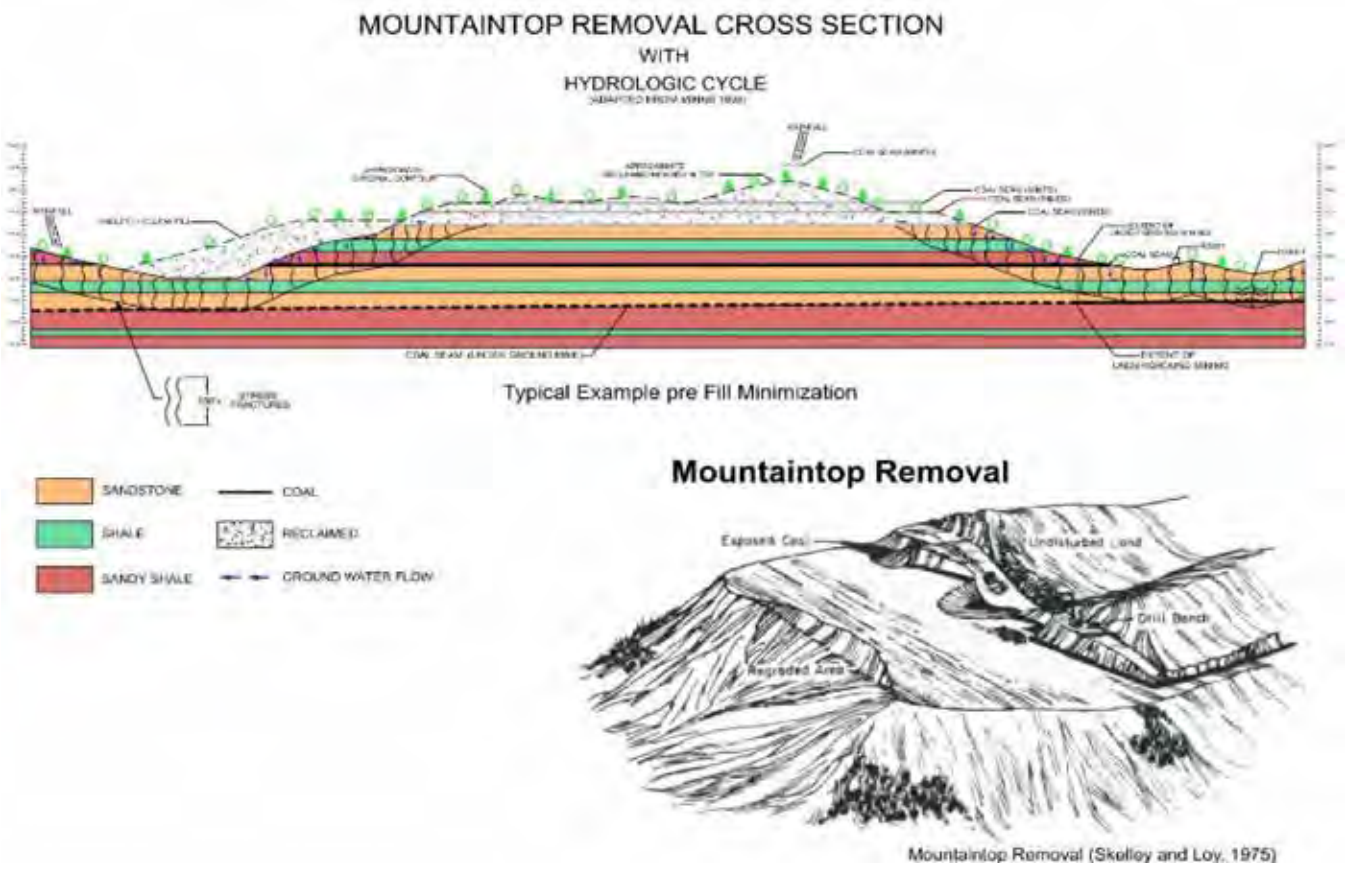
West Virginia receives adequate amounts of sun, but its laws and policies have been less than favorable for any significant solar power development. As a major historical producer of coal, the West Virginia state legislators have been particularly averse to consideration of most types of alternative energy development. West Virginia has also recently benefitted from the shale gas expansion, which further hinders the implementation of policies to encourage the development of alternative energy resources. West Virginia's electric rates are ranked 36th cheapest out of the 50 states with retail rates significantly below the national average. West Virginia is a regulated electricity market where electricity sales must pass through the utility. This is significant to the West Virginia solar market because it prohibits third party power purchase agreements or net metering credit purchase agreements.

Opportunities for solar electricity sales — The regulated nature of the West Virginia electricity market presents a challenge to solar proliferation. In the absence of third-party electricity sales avenues, there are three primary avenues for solar project development in West Virginia:

- A utility customer can purchase a solar generating system and use the power produced by the array to offset his or her electric load "behind the meter" through a net metering arrangement.
- A solar project certified as a Qualifying Facility under Section 210 of PURPA can choose to sell the electricity to the local electric utility under the provisions of the utility's applicable riders or tariffs.
- Regulated utilities may self-develop solar projects on behalf of their customers. When utilities decide to self-develop solar, they often need the

Figure 3

Schematic of mountaintop removal process.



approval of a regulatory body, such as a public service commission, to earn a return on the cost of the solar investment from the rate base. To receive regulatory approval to develop solar, utilities must often demonstrate that the cost of the solar is equal to or lower than the cost of supplying customers with the electricity through an alternative means.

Barrier and opportunity analysis — West Virginia

While West Virginia does not presently have facilitative rules incentivizing solar development compared to many other states, it does have many sites appropriate for solar. That is important because solar installations can occupy large areas of land, land generally scarce and highly priced in the more populous areas in the eastern portion of the country. With the continued decentralization of power generation coupled with improvements in the transmission system of the Appalachian and Mid-Atlantic regions, the abundance of good sites in West Virginia should become more compelling to solar developers. One of the current barriers to solar development in West Virginia is the lack of a clear pathway to selling the electricity produced by the projects. To facilitate the creation of a robust solar market in West Virginia, regulatory and policy adjustments need to be made to provide solar projects with additional options for the sale of electricity. Below are recommendations identifying areas of opportunity to facilitate the sale of electricity from solar projects located on mining properties:

- Enable third party electricity sales — The primary obstacle to solar projects in West Virginia is the prohibition on third-party electricity sales. This obstacle necessitates a customer owns a solar array to receive electricity from it. Many states have built robust solar markets based on third-party electric sales. In this scenario, a project developer will pay for the construction of the array and then own and operate the asset for the long term. The developer will sell the electricity from the project to a customer at a discounted rate enabling the customer benefits through savings realized on their electric bill. This business

Figure 4

84-ha (208-acre) permit.

arrangement eliminates the need for the customer to have to pay a large upfront payment and effectively makes solar more accessible.

- Green tariffs — Utility "green tariff" programs enable utility customers to purchase electricity generated by alternative energy sources through their utility by opting into a special service arrangement. Green tariff programs have been essential to the growth of many solar markets by increasing the demand for solar projects as utility customer's elect to power their operations with solar and wind energy. Green tariffs are particularly important in regulated states, as they empower utility customers who have not traditionally had the ability to control their electric supply to elect to receive electricity from alternative energy projects.
- PURPA rules — Alterations to the existing rules for qualifying PURPA project offers an opportunity to facilitate solar development in West Virginia, without having to undergo substantial market reform by enabling third party electricity sales. Many states with regulated electricity markets, such as North Carolina, Utah and South Carolina, have developed strong solar markets largely through the use of PURPA contracts allowing qualified facilities to sell electricity back to the utility.
- Alterations to net metering — The following suggested changes will have minimal effect if the more foundational challenges around electricity sales from solar projects in West Virginia are not addressed:
  - Co-location: Many states have regulations proscribing only a single solar project can be deployed on a legal parcel. Many West Virginia mine sites are very large legal parcels, having the potential to host multiple projects. Eliminating single parcel rule or explicitly permitting the co-location of solar projects on mining properties will encourage the development of multiple projects on former mining properties.
  - Net metering project capacity limits: In West Virginia, industrial projects have a net metering capacity limit of 2 MW, commercial projects have a net metering capacity limit of 500 kW and residential projects have a net metering limit of 25 kW. Raising the net metering capacity limits will

Figure 5

32-ha (79-acre) permit.

help facilitate the development of larger projects.

- The 2-Mile Rule: The definition of a Customer Generator states the project must be located within 3.2 km (2 miles) of the electric load receiving the net metering credits. As many former mineral extraction sites are in relatively remote locations, there are rarely large electric users within two miles. Modifying the definition of a customer generator to enable the value of electricity to be net metered to remote energy consumers will drastically increase the pool of potential participants in net metered projects, further stimulating solar development.

- Standardization — Solar markets thrive on standardization and the minimization of variability that may adversely impact project outcomes. One of the greatest sources of uncertainty for ground-mounted solar projects is the permitting process. Providing standard solar education and regulatory support documents to West Virginia communities and relevant agencies will help ensure solar development is regulated in a consistent, practical manner.
- Interconnection opportunity analysis — Developers and investors want to ensure considerable time and development expenses are not spent on cost-prohibitive projects to interconnect to the electric grid. State regulatory bodies and utilities can stimulate investment with:
    - Pre-application reports.
    - Interconnection maps.
    - Queue transparency.
    - Digital applications and electronic signatures — Relaxed interconnection application levels.

Site selection criteria – West Virginia model

The available surface area of a permitted mine location is a primary criterion. ECSI, now SynTerra began by choosing a minimum permit area of 16 ha (40 acres). In addition to the desired size of the site, the status and condition, both current and future, are important aspects to a planned development site. Using the West Virginia mine-permit database, permits were filtered by bond-release status. Permits having completed reclamation and fully bond released are considered completely released. Sites completely released are readily available for solar development provided an agreement

Figure 6

Hatfield & McCoy solar project.

between the land owner and solar developer can be reached and the land was reclaimed to slopes and vegetative cover suitable for solar panel installation. Active reclamation sites are advantageous as the land can be shaped for solar development.

The mining method associated with the permit is possibly even of greater importance than its status. The mining method chosen will determine the type of disturbance that will occur at the site. In West Virginia, a region of extreme topography, the choice methods of extraction are area, contour, and underground mining. Area/Mountaintop mining yields the best scenario for solar development since this method would provide the largest and relatively flat surfaces at the top elevation of the mountain.

Even on mine sites with a mining method conducive to solar development, there will still be physical limitations to be considered. Conditions such as land slope can affect the suitability of a site. For sites using solar panels mounted on skids, a maximum land slope of 5°-8° (approx. 11.5:1 to 7:1) can be tolerated. For sites using pipe anchoring, a maximum of 15° (3.75:1) is often permitted. The soil/rock materials used for grading and backfilling during reclamation of the site can also be a factor. Most mine sites use spoil from the mining process, which is a combination of soil and waste rock from either the extraction or the processing stages. Some backfill materials are better suited to support a load from a solar array than others. The vegetative cover of the site is equally important. Thus, prospective sites requiring minimal earthwork or clearing to install arrays are preferable, as they will have lower construction costs; and sites reclaimed for a number of years and have permanent vegetation with established trees would be less attractive than a site with little to no growth.

Proximity to the electrical grid is a key factor to the development of a solar installation. Developing utility infrastructure can be extremely costly and significantly affect the financial feasibility of an installation. ECSI, now SynTerra, has attempted to limit the maximum range a potential site can be from a substation to three miles. While this selection may be tightened to an even shorter distance, a range of three miles provides access to many of the substations throughout the state.

While the number of substations present and population density tend to correlate, they also need to be analyzed separately. Substations are required for transmitting a load, however, they are not always an indicator of the actual demand for it. Population centers or potential industrial users should be near and large

enough to justify installing a solar installation.

Access to potential sites has also been considered. Though not by itself a disqualifying factor, site access should still be considered when prioritizing the sites. Many mine sites are in rural areas miles from a major state or U.S. highway. Geographical limitations such as this can increase the logistical and financial burden on the developer and make both construction and maintenance costs higher in the long term. Solar modules, racking components and inverters are typically delivered to project sites by the truckload, and increasing the complexity of the equipment delivery can have a corresponding increase in project cost.

The relationship with landowners will also be a major variable in site selection. Favorable relationships can yield an accelerated timeline and freedom of mobility, whereas a resistant land owner can shut down a prospective site altogether. Most landowners are at least open to considering a development project, given a vision for economic growth for the community and a sufficient financial incentive.

Partnering sites, such as those located at or near schools, prisons, industrial parks, commercial, residential or recreational sites, may generate an isolated demand. While producing less revenue than a larger population, they can create more favorability on the policy side. Pilot projects partnering with these institutions may be a strategic avenue to creating more opportunities in the future.

Site selection process — West Virginia example

The site selection process began with the EPA document "Re-Powering Screening Dataset – August 2015." This dataset included more than 2,100 individual records listed as a West Virginia Abandoned Coal Mine Area type with potential for solar development. The latitude/longitude data were combined with shapefiles for the West Virginia abandoned mine land sites and imported into Google Earth Pro.

The study team's initial review of the EPA dataset using Google Earth imagery revealed the dataset also included many underground mine sites, contour surface mining areas and acid mine drainage sites, in addition to any useable mountaintop surface mining sites. A review of the areas using the Google Earth imagery also quickly revealed that very few of the sites listed in the EPA dataset would offer any favorable potential for any utility-scale solar development facilities.

Following this initial review and relative dismissal of data provided in the EPA's Re-Powering dataset, the study team directed

efforts toward the West Virginia mine permit database to garner additional information on potential available mine sites. The state's permitting database contains records for mine permits in various stages of active mining and reclamation, therefore, it was necessary to first sort and download the record data accordingly.

The study team initially concentrated on obtaining records for mine sites that had gone through the entire reclamation and bonding process and obtained complete release status. Realistically, these sites would likely be more readily obtainable without any attached permitting requirements yet to be fulfilled. The team also downloaded data for other sites listed in the database as "Active with Reclamation;" "Active Reclaimed;" "Phase 1 Bond Release;" and "Phase 2 Bond Release," since these sites would also have some potential now or in the future as possible solar development sites. In addition to the download of mine data in spreadsheet format, the permit shapefiles were also downloaded for each of these categories. These permit shapefiles were then imported into Google Earth Pro to allow a visual analysis of the permit against recent satellite imagery.

The number of West Virginia permit sites downloaded for further analysis totaled 741 and the number in each permitting category were as follows:

- Completely released: 436 sites
- Active reclamation only: 68 sites
- Active reclaimed: 127 sites
- Phase 1 bond release: 73 sites
- Phase 2 bond release: 37 sites

The study team's initial visual evaluation of a site's potential for solar development included looking at the acreage and configuration of the permit area; slope or flatness of open areas; amount of vegetation or level of reforestation on the site; existing site access; and apparent current use of the site. Preference was given to sites with relatively large areas free of well-established vegetation, with no apparent current commercial or farming use, and near connection points to the electrical grid. Some sites were also identified that could serve as a local community use, such as sites adjacent to schools, commercial developments, industry, prisons or small communities.

An important revelation derived from the download of West Virginia permit information was not all previous mine sites appear to be included in the database. This is possibly due to some of those sites being mined prior to the 1977 enactment of the Surface Mining Control and Reclamation Act are not part of the AML database. Satellite imagery shows some of these areas may also offer reasonable potential for solar development. In fact, some of the older mined and reclaimed sites may offer more attractive potential because they were often left in a flatter and more useable condition than more recent reclaimed sites. Current reclamation laws often require the site be returned to AOC, which entails placing excess spoil material back at the top of the mountain to emulate the previous mountaintop conditions. Older mining sites typically placed excess material in valley fills and often left large flat areas available for development.

Electric transmission line corridors and electric substation locations were also downloaded and imported into Google Earth for use in aiding the assessment of potential sites in relation to electric grid connection availability.

Identification of potential sites solar development — West Virginia example

All 741 sites listed for the five permit categories were evaluated for potential solar development through a visual analysis using permit boundaries overlaid on Google Earth imagery (Table 1). The visual analysis considered topography, vegetative cover, proximity to existing substations, nearby population areas and potential power users. Sites demonstrating at least some potential were then ranked on a scale of 1 to 5, with a ranking of 1 being low potential, and a ranking of 5 being high potential.

Table 1 summarizes the results of the evaluation exercise for each of the permit categories:

Both sites given the highest rank of 5 are a product of mountaintop removal method (Fig. 3). Both sites are in complete release and offer approximately 22 ha (55 acres) suitable for solar panel installation (Figs. 4 and 5).

Roadmap to future

The current climate for solar development in West Virginia is not conducive for a variety of reasons, primarily regulatory barriers. The pressure to enact any legislative changes will have to come from outside of the state government. This pressure could come from a combination of sources, including utility companies, large corporations, large landholding companies or the public.

Large international corporations will likely become the primary drivers of solar

Table 1
Potential sites for solar development.

Permit category	Total No. of permits	No. of sites with some potential	No. of sites with ranking of 5	No. of sites with ranking of 4
Complete release	436	86	2	14
Active reclamation	68	21	0	6
Active reclaimed	127	34	0	7
Phase 1 bond release	73	16	0	3
Phase 2 bond release	37	9	0	2

development by providing the necessary impetus to implement changes in the current regulations and policies and move them in a direction more favorable toward alternative energy in West Virginia. These companies typically operate and have multiple facilities throughout the United States and around the world. Many of the largest international corporations have already established corporate-wide sustainability goals and are committed to securing predictable energy cost structures for their future energy needs. A recent report by Advanced Energy Economy found that 71 of the Fortune 100 companies currently have alternative or sustainability targets and that sustainability commitments among Fortune 500 companies is at 43 percent, or 215 firms. Many of these same firms have made an even more advanced sustainability statement by committing to the RE100 Initiative — to achieve 100 percent of their power needs through alternative sources by a given date. As of January 2018, the RE100 Progress and Insights Report, states that 122 leading international corporations have committed to sourcing 100 percent alternative electricity, with 42 of those companies being headquartered in North America. Companies committing to the initiative grew by 40 percent in FY2017 alone. Many landowners are looking for replacement revenue due to the downturn of mining in the region. Some of these landowners have holdings that are completely mined-out or will be uneconomical for mining in the foreseeable future. Historically, a large percentage of West Virginia land has been under the ownership of absentee owners.

The Hatfield & McCoy Solar Project is a planned 283 ha (700-acre), 100 MW solar array installation in Pike County, KY being developed by EDF Renewables. Solar energy harvested by this project will be sold to the PJM distribution network (Fig. 6).

The Hatfield & McCoy Solar Project combines the promise of low-carbon footprint technology of solar power with the beneficial use of previously mined, mountaintop land that has been left in a configuration suitable to develop power generation on the scale required to deliver wholesale electricity to the nation's grid. What is unique about this project is the use of former coal mining property, which produced tens of millions of tons of high-quality coal used in the generation of electric power, to provide a platform amenable to continue the production of electric power from the same property.

ECSI, now SynTerra, was contracted to perform a variety of services in advance of solar panel installation. Initially, a grading plan was developed which incorporated the mining and reclamation plan of the on-going Bent Mountain Surface Mine permitted by Kentucky Fuel Corp.. The grading plan was developed to maximize contiguous tracts of flat or gently rolling acreage with slopes of no greater than 5 percent. Up-to-date drone-generated topographic mapping was utilized in conjunction with publicly available LiDAR contour coverage to establish a current baseline to work from. Computer software was then applied to the existing grade and proposed grade to graphically identify areas of varying ground slope. The grading plan was then massaged to meet the project developer's requirements while minimizing re-handling and excessively long haulage of spoil as part of the reclamation process.

It was recently announced that automaker Toyota was planning to announce a major investment in solar and other alternative energy in Appalachia and the Southeastern United States. The plan was said to include a massive new solar facility on an old surface coal mine property in Kentucky. The report also said that the Kentucky site was just part of a much larger plan to purchase as much as 800,000 MW hours per year, or roughly 365 MW, of alternative energy, primarily from developers in Appalachia and the South. ■