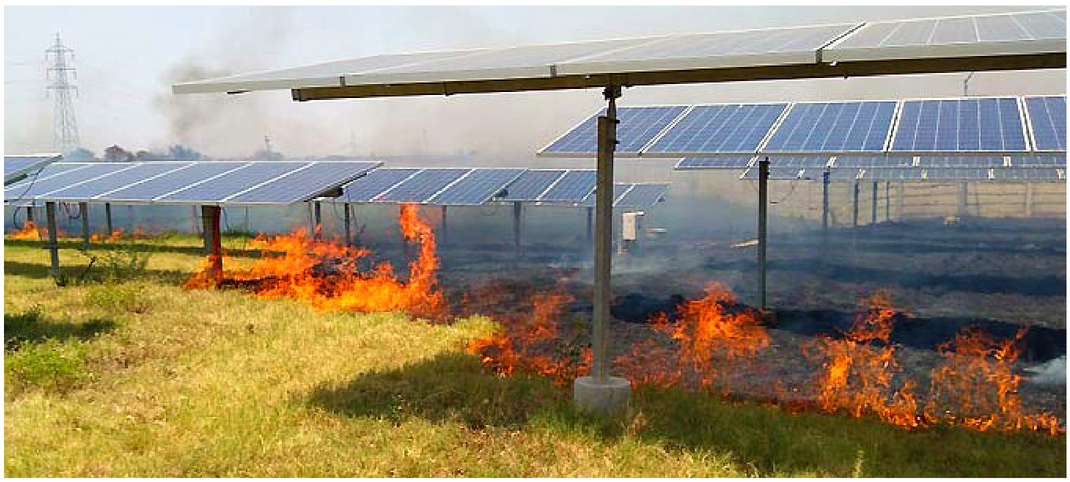
AEGIS

Loss Control

Wildland Fire Hazard Risk Reduction for Solar Photovoltaic Sites

White Paper



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Disclaimer

Wildland fires will continue to exist, whether the result of natural or human causes, and we will need to address the inherent risk they pose to solar photovoltaic (PV) sites. This paper is not intended to be a review of applicable local, state or federal requirements, nor is it a substitute for expert advice. Rather, it is intended to offer guidance to our members to help them reduce risk from an insurance perspective, and nothing contained herein should be interpreted as a replacement for a Wildland Fire Hazards Mitigation Plan.[1] Neither the authors nor AEGIS Insurance Services, Inc. endorse or guarantee that any particular practice or procedure described herein is safe in all cases or meets any code or regulatory requirement. This paper is provided without warranties of any kind. It should not be used or distributed in part or as a whole without the written consent of AEGIS Insurance Services, Inc.

Introduction

As the size and number of solar photovoltaic generating sites increase, so do the associated hazards that must be addressed. Specifically, the risk of loss due to wildland fire has also increased and can result in losses in the tens of millions of dollars. There are many variables that factor into the risks associated with wildland fire, which include but are not limited to the location of the site, lightning activity, humidity, type of fuel, moisture content of fuel, fuel loading or depth of fuel, and wind speed.

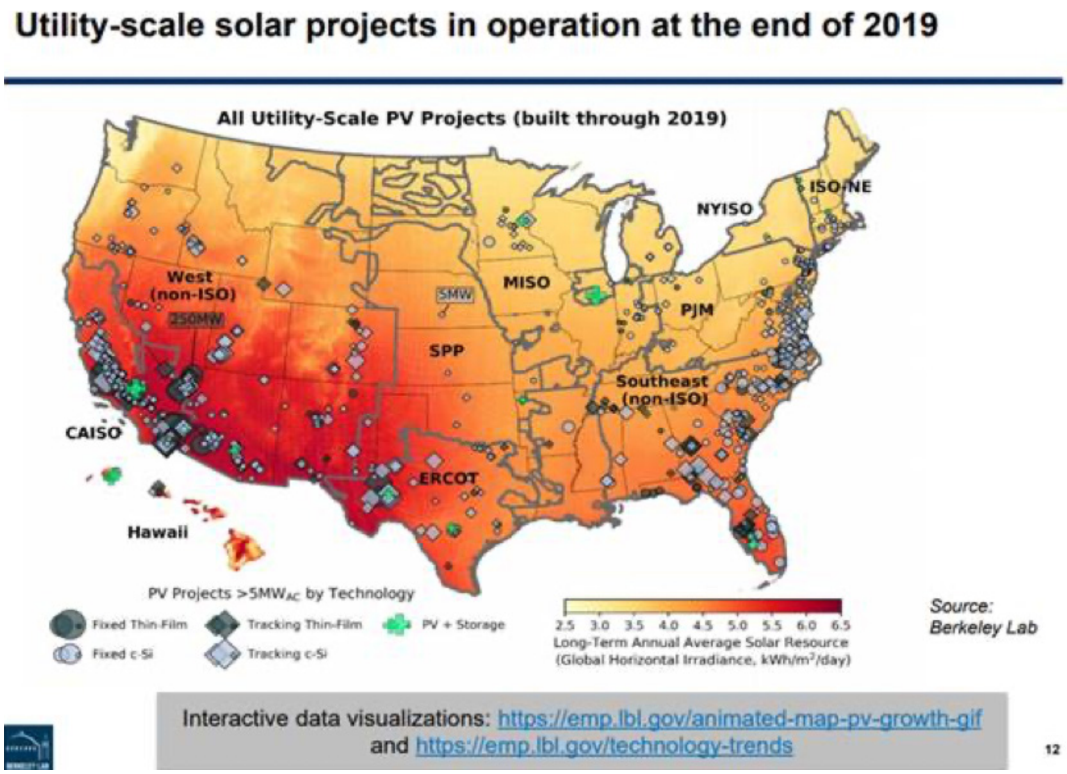
Wildland fire exposures can result from either exterior fires or vegetative fuel from within the PV solar site. Under the right conditions, such as a Red Flag Warning, wildland fires can grow from ignition point to several hundred acres in a matter of minutes. Red Flag Warnings are issued by the National Weather Service to inform the public, emergency responders and other agencies that conditions are ideal for wildland fire combustion and rapid spread. The criteria used for determining warning conditions are a sustained wind speed in excess of 15 mph 20 feet above the ground, a temperature greater than 75° F, and a relative humidity of 25 percent or less. As these fires grow, flames can reach more than 10 feet high and flame fronts can easily stretch a quarter-mile wide. They can become large, fast moving fires that create their own winds, produce flying brands (airborne burning embers) and preheat fuels far ahead of the actual fire. These conditions make them difficult to control and extinguish, which increases the risk of loss at solar PV installations.

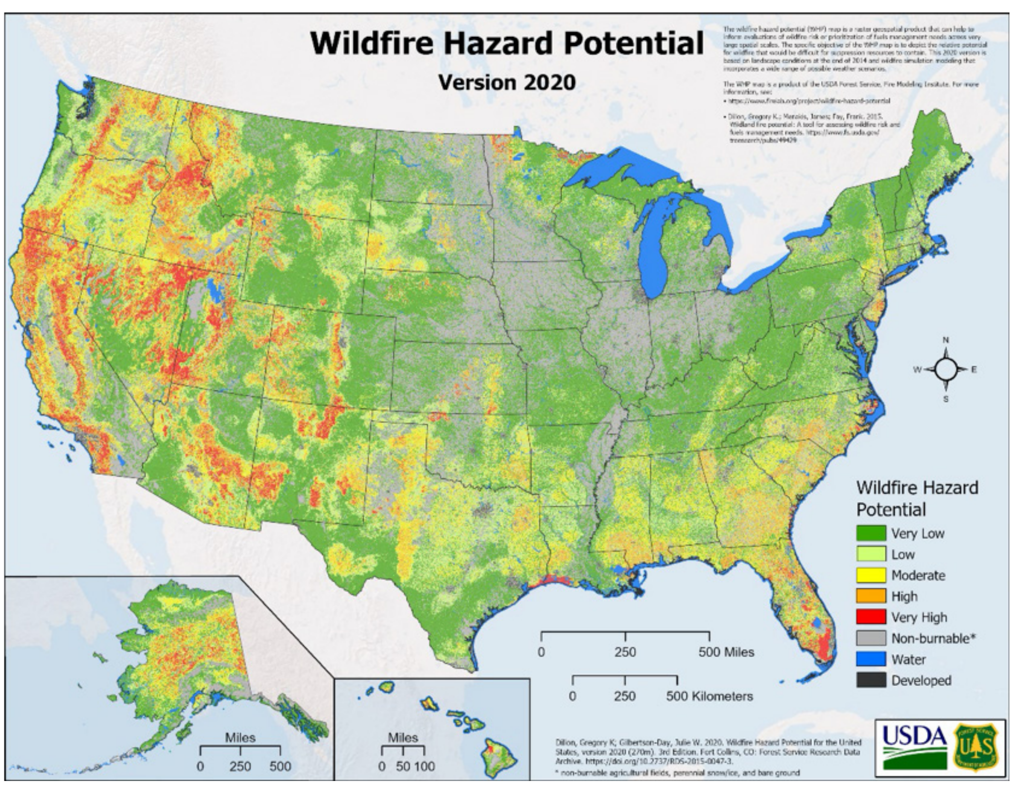
Background

Wildland Fire History and Exposure Concerns

Data from the National Fire Protection Association (NFPA) Research Foundation[2] indicates that from 2011 to 2015, local fire departments in the U.S. responded to an average of 306,000 brush, grass and forest fires per year, or the equivalent of 840 fires per day. While the majority of the fires remain small and are contained to less than 10 acres, there has been a significant increase in much larger fires. For example, in 2014, the total acreage involved in wildland fires was 3.6 million acres. By 2018, that had grown to 8.8 million acres.[3] As the acreage involved in wildland fires increases and the construction of solar PV sites grows, the risk of wildland fires affecting those sites also increases.

The following maps further illustrate the risk of wildland fire to solar PV sites. The first depicts current and planned utility scale solar sites, and the second depicts the potential for wildland fire in specific areas.





Controlling or eliminating vegetation is a key factor in the construction of solar PV sites and in the construction of the PV panels themselves to reduce the loss from a potential wildland fire.

As previously mentioned, flame heights can easily top 10 feet, depending on the type of vegetation fueling the fire. Fire service information[4] indicates that under the right conditions, grazed grassland pasture with grass 3 to 4 inches in height can generate flames up to 3 feet high under the right conditions. Computer modeling from the U.S. Department of Interior Interagency Fuels Treatment Decision Support System[5] further illustrates a variety of wildland fire behaviors. The model supports 58 different types of fuel environments.

The following five fuel classes were chosen as examples of locations where solar PV installations are likely be located. The model incorporates fuel factors, moisture content and wind speed in order to determine flame height on level ground. The most conservative parameters were selected for this exercise, and the 15 mph wind speed correlates to Red Flag Warning conditions.

Selected Fuel Classes and Flame Height (5 of 58 classes in the U.S. Department of Interior Interagency Fuels Treatment Decision Support System model)

FM1

Fuel class FM1 – Short Grass. These are grasslands, savannah, grass tundra, shrub, and stubble.

FM1 – Flame height with 15 mph wind = **5.8 feet**

GR1

Fuel class GR1 – Sparse Short Dry Climate Grass. Sparse grass with fine amounts of dead fuel, which may be sparse or discontinuous.

GR1 – Flame height with 15 mph wind = **2.5 feet**

GR3

Fuel class GR3 – Low Load, Coarse Humid Climate Grass. Continuous, coarse, humid climate grass. Low load fuel bed depth of about 2 feet.

GR3 – Flame height with 15 mph wind = **11.07 feet**

SH1

Fuel class SH1 – Low Load Dry Climate Shrub. Woody shrubs, some grass may be present. Fuel depth of about 1 foot.

SH1 – Flame height with 15 mph wind = **4.01 feet**

SH5

Fuel class SH5 – High Load Dry Climate Shrub. Woody shrubs and shrub litter. Heavy load with fuel depth of 4 to 6 feet.

SH5 – Flame height with 15 mph wind = **23.70 feet**

Photovoltaic Panel Exposure

Wildland fires involving short grasses, such as fuel class FM1 and GR1 or grazed pasture-land, can represent a severe threat to solar PV arrays either through direct flame impingement or radiant heat. The back sheet material of a solar panel is a critical factor in the maximum exposure to heat/flame a panel can withstand. Many solar panels are constructed with plastic back sheets and exposed cabling, so even a short-duration fire could cause the complete loss of the panel or array.

The back sheet on a PV panel is the protective layer that prevents moisture infiltration. Back sheets are usually made with some type of either polyolefin plastic, polyethylene terephthalate (PET) or PCB material. Polyolefins, also known as polyalkenes, PET and PVC, are all thermoplastics, meaning they melt and deform when exposed to heat.

Back sheets are typically very thin, on the order of 300 microns, or 0.012 inches thick, which equates to about 11.8 mils. By comparison, a heavy plastic trash bag is approximately 3 mils thick. The back sheet will be compromised by minimal heat, even if it has been treated with fire retardants to prevent ignition.

Flame temperatures in the 367° F range can be expected from free burn vegetative grassland matter, according to *Journal of Range Management* research.[6] Temperatures are higher when the vegetation includes any woody mass. The melting temperature of a polyolefin back sheet will generally be in the mid-200° F range. PET has a higher melting temperature of 500° F, but becomes soft and pliable above 284° F. PVC, depending on how it is made, has melting temperatures of 212° F to 500° F, but may begin to deform at temperatures as low as 198° F. Once breached, deformed or compromised in any way, the panel must be replaced.

Vegetation Management

Planning and Budgeting

Vegetation management is critically important. It should be included at every stage of the project, from initial planning all the way through to commercial operation, as part of recurring costs in the annual operation and maintenance budget. On average, vegetation management can account for up to 4 percent of the total O&M cost.

Mechanical and Other Issues

In addition to the fire hazard exposure, uncontrolled vegetation growth at the site can lead to additional equipment-related issues that can affect system performance and lead to lost generation (output). These issues include:

Shading. Vegetation growth partially covering or shading the panels can decrease the panel's output.

Hot spot creation. If a part of the solar panel is shaded, the cell can heat to extreme temperatures that cause burnout and permanent damage.

Infestation. Wildlife, including insects and snakes, can threaten the safety of workers at the site.

Methods for Vegetation Management

Various methods are available for control and management of sites with established vegetation. All offer both advantages and disadvantages.

Herbicides are often easier to administer and less costly and time consuming than other means of physical control. The disadvantages include the potential harm to workers applying these chemicals and harmful environmental consequences.

Herbivore grazers are also an option. Sheep are generally better suited for this purpose because they are docile and tend to eat only the vegetation. Goats, on the other hand, can damage equipment by climbing on the panels and eating the wiring. Grazers have several drawbacks: supervision is needed; some animals may not prefer the type of vegetation present; precautions are required to prevent them from chewing on system components; and they may inadvertently activate security systems.

Mowing is the most basic means of vegetation control. It must be done often and can be labor-intensive, although robotic mowers are available. Perhaps the biggest drawback to mowers is their potential to ignite wildland fires. Mowing, particularly the use of string or blade trimmers, can also damage the panels, wiring and, especially, the delicate plastic backing on PV panels.

Physical means, including weed-controlling fabrics or sheets or the use of an aggregate substrate material (similar to what is found in an electric substation) are the most effective ways to control vegetation. They require minimal periodic maintenance or vegetation removal, but they do come with a significant initial cost and may be difficult to implement at an established site. High winds may lift fabrics if they are not secured properly.

Wildland Fire Hazards Mitigation Plan

Plan Overview

Established sites as well as projects in development should have a Wildland Fire Hazards Mitigation Plan.[1] The plan should outline the overall strategies and responsibilities necessary to reduce or eliminate the exposure due to fire and heat. For a plan to be effective, an ignition risk assessment and fuel hazard assessment should be completed as part of plan development.

Risk Assessments

An ignition risk assessment is an evaluation of potential ignition sources including but not limited to weather-related sources, transportation roadways, railroads, utility corridors, nearby industrial operations, nearby recreational areas, and intentionally set fires.

A fuel hazard risk assessment includes evaluations of the vegetation type, surrounding terrain and siting, weather conditions and their effect on vegetation, the direction of normal prevailing winds and the fuel load in that direction, fire behavior external to the facility, and fire history for the surrounding area.

Plan Development

Once risks and hazards are identified and evaluated, the mitigation plan can be written and implemented. Elements of the plan should include, at a minimum, mitigation activities, responsible parties, priority for each activity, and a schedule. Activities may include fuel growth and ignition source monitoring, fuel treatment and control, and weather condition monitoring. Other elements to consider are the establishment of fire breaks, fire barriers, and clear spaces. Fuel growth monitoring and fuel treatment will be required activities from project inception through commercial operation.

The plan should also include preparedness and pre-planning activities with local emergency responders. In most cases, a wildland fire affecting or involving a solar PV generation facility will be part of a much larger overall event. The plan should designate liaisons with emergency response organizations and include any Incident Command training needed to be incorporated into the Incident Management/Unified Command structure.

Once a plan has been developed, it should be reviewed annually and updated as needed in order to address current conditions.

Model Practices and Guidelines

Ultimately, complete vegetation removal at the site is the preferred method for reducing exposure to wildland fire. At sites where vegetation has been removed, the application of an aggregate substrate material will help control soil erosion. While the external exposure remains, it is significantly reduced due to the lack of fuel at the site. This method of mitigation is most easily accomplished during initial site construction.

For established locations, complete vegetation removal also remains the best method, though it may be difficult to achieve. For locations with established vegetation, the best overall strategy includes both active and passive methods of fuel control. The active methods are managing and controlling vegetation growth, while passive methods include creating clear space fire breaks to prevent or minimize fire spread.

Vegetation under or near solar PV panels should not be more than 6 inches high and may need to be reduced even more depending on seasonal conditions. Additionally, if at any time, any part of the panel, such as with a tilted panel, is within 36 inches of the ground, even if the underlying vegetation is primarily grass, the vegetation should be completely removed. If the vegetation is a mix of grass and short shrub similar to fuel class SH5, it should be removed completely, regardless of panel height.

All sites should have a perimeter fire break that is free of vegetation. Wildland fire exposure from an external fire can be mitigated by creating a defensible space around the site. The perimeter fire break should be bare ground or covered with an aggregate substrate to limit soil erosion. The perimeter fire break can be inside and/or outside the perimeter fence, and should be at least 50 feet wide and potentially wider depending on the site's environmental conditions. It can be helpful to conduct a meteorological analysis to identify external environmental parameters that may have an effect on fire behavior and the site.

Additional fire breaks are necessary for locations with established vegetation to prevent or minimize fire spread within the site by interrupting the line of vegetation. The space between solar panel rows should be kept free of vegetation, and any space breaks in panel rows should also be cleared of vegetation. A 10-foot-wide clear space fire break should be established around transformers, electrical equipment, and any buildings, structures, or enclosures.

Conclusion

This paper is intended to help members eliminate, mitigate or reduce the wildland fire risks associated with constructing and maintaining solar PV generating sites. With the shift to renewable generation and the increase in both the number and size of solar PV sites, the "value at risk" also increases, for members and AEGIS.

References

1 National Fire Protection Association 1143, "Standard for Wildland Fire Management," 2018 Edition

2 National Fire Protection Association report "Brush, Grass, and Forest Fires," Marty Ahrens, September 2018

3 National Interagency Fire Center

4 New South Wales Rural Fire Service

5 U.S. Department of Interior Interagency Fuels Treatment Decision Support System Fuel Modeling

6 Arthur W. Bailey and Murray L. Anderson, "Fire Temperatures in Grass, Shrub and Aspen Forest Communities of Central Alberta," *Journal of Range Management* 33, January 1980

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