Rise of the machines

Aerial monitoring | With PV projects growing larger and fleets more dispersed, new technologies are emerging to assist plant managers look after their assets. Tom Kenning looks at the growing use of solar drones and robots in plant operations

Despite controversial uses in military actions across the globe, drones have now crossed over into the mainstream commercial sector with a deluge of recent enterprises ranging from Facebook considering solar powered drones to deliver internet access and Amazon testing package delivery via the skies. However, these unmanned aerial vehicles (UAVs) have already become popular with members of the energy industry, who have been using them with thermal imagery to check oil and gas pipelines, wind turbines, construction projects and even to monitor vast PV power plants.

With PV plants and fleets becoming ever larger, the sight of drones flying low over solar installations at speeds of up to 50 miles per hour is becoming increasingly common. Furthermore the necessity to clean PV panels has led to a rise in robot systems used to wipe clean the panels and prevent build up of soiling and dust, which can undermine the optimal operation of a plant.

The global commercial drone market is forecast to grow at a compound annual growth rate of 109% from 2014 to 2020, according to the 'Commercial Drones Market 2013 – 2020' report from MarketsandMarkets, and the energy and infrastructure industries are the cited as main driver for this.

A primary concern in the PV community is quantifying degradation and failure rates of modules and cells in the field. Even though a US National Renewable Energy Laboratory (NREL) study estimates that PV panels suffer a failure rate of less than 1% per year, the effects on energy output builds up over time. Knowing degradation rates and pinpointing faulty cells and modules can help accurate predictions of a plants future output and reduce financial risks.

Timothy Silverman, scientist at NREL National Centre for Photovoltaics, tells *PV Tech Power* that surveyors traditionally perform periodic plant inspections using handheld cameras. In many cases, it is not cost effective to have someone check every single module in the field so they perform spot checks to look for obvious issues. Thus, depending on the size of the plant, using UAVs for flyover inspections may give better, cheaper and more efficient coverage.

Source: Skycatch.

Unmanned aerial vehicles – drones – are becoming a common sight over PV power plants.

PV panels emit a certain amount of heat, and defective panels give off more heat than functioning panels. Therefore the difference in temperature can be easily detected using an infrared thermal imaging camera.

Vigilant Energy Management, for example has used a drone purchased from Canada-based manufacturer Dragonfly on six sites ranging from 1 to 5MW over the last six months. Even for relatively small plants, the drones have the advantage of surveying solar arrays quickly and spotting anomalies using infrared from a long distance, says Jeff Gilbert, Vigilant director of operations and maintenance services.

He says it takes half a day to walk a 1MW site and just 30 minutes to use a drone. "Simply spotting a hot module cell quickly is much more valuable than high resolution images from the ground," he explains.

Historically Gilbert would hire a helicopter or aeroplane to take high resolution pictures for marketing, but now he uses the drone. He concludes: "The prices are coming way down and the uses are going way up. We think it is a good investment."

Products from Google-backed drone manufacturer Skycatch are widely reported to have been tested by industry giants First Solar and SolarCity. Eugene Kwak, Skycatch director of product, hardware platform, told *PV Tech Power* that users can programme in automatic unmanned flight missions for the drone and create maps, while maintaining accurate performance in strong winds. The camera can then spot physical anomalies within a cell, such as physical cracks and cell discoloration, using an RGB sensor.

Meanwhile Italian-based drone developer Panoptes has customised remote controlled drones for thermographic inspections of PV plants. These automatically produce inspection reports using

mT-Panoptes 640 drone:

- Inspects 5-15 MW in one day
- Each day of surveying requires one or two days of post-processing
- Experienced UAV pilot needs five hours training for use
- System weight 700 grams
- Uses HR thermal imager and HD camera

software called 'Solar Inspector', which assist O&M managers in subsequent ground checks.

Silverman says that newer drone applications are emerging with the introduction of electroluminescence (EL) and photoluminescence (PL) imaging. While thermal imagery detects external temperatures, EL and PL techniques take a picture of the emission of the active layer of the material itself.

Meanwhile UAVs can also be used to check cabling, wiring, infrastructure and mounts, or for topographic and feasibility surveys of potential solar plant sites. Drones are even being used to ward off birds and endangered species from functioning PV plants, with bird deaths a politicised issue that can undermine whole projects.

Source: Ecoppia.

Robotic cleaning units save water and labour at large or inaccessible PV sites.

Robotic cleaning

Besides inspection, another concern for PV operators is soiling and the necessity to keep panels clean from thin layers of sand and dust to ensure maximum efficiency in harvesting the sun. Silverman says: "Whether you should clean at all depends on how much soiling you get. In locations like India it is really common to clean twice a month because the plants are so dusty and the lost energy from the soiling would more than pay for the cost of cleaning, but in Colorado, for example, soiling is not too bad and precipitation is just frequent enough to clean off that soiling – so here it doesn't really make sense to do cleaning."

The majority of large-scale installations globally, however, are located in desert areas to get as many sun hours as possible. This not only brings a challenge of dust and soiling but also water scarcity. Anat Cohen Segev, director of product marketing for Israel-based cleaning robot manufacturer, Ecoppia, says this is especially the case in the Middle East, India, Northern China, California, Arizona and South Africa.

"So far the cleaning methods used were primitive – often manual cleaning with squeegees and pouring water," Segev says. "Recently there have been solutions with vehicles driving between the arrays carrying water and that is either being sprayed on the panels or using long brushes, but in any case it is a very costly solution." These techniques using pressure washers and sprayer trucks also have the potential to damage the highly expensive PV equipment while water also requires distillation to avoid panel corrosion.

A vast range of robotic applications have been developed. SunPower acquired Greenbotics and its CleanFleet robots in 2013, which can be configured for use with a variety of solar panels including fixed-tilt arrays and single-axis trackers.

Ecoppia's robot cleaners, on the other hand, are fixed permanently to rails on an array. Powered by their own solar panels, using neither water nor labour, the robots clean automatically each night. Dust sticking to the panel is considerably reduced and output kept high. Automisation also negates problems with predicting dust storms.

Esther Westreich, chief executive of Global Sun Operation and Maintenance at Arava Power Group, which uses Ecoppia robots at its 20-acre Ketura Sun solar farm in Israel, tells *PV Tech Power* that even after a dust storm the Ecoppia robots have the panels clean in an hour. "It has a positive effect on production of a few percent, which is quite significant for this scale of a project," Westreich says.

She says the robots do not touch the panel, except for the gentle microfibres that do the cleaning, which minimises any potential for damage. This solution works best on plants with long rows and lots of panels as they can only be fitted to rails.

Ecoppia robots, which are deployed on six plants in Israel and several in India and the Middle East, clean five million panels every month and are expected to be cleaning 10 million a month by 2016.

The case for using drones and robots is clear for large-scale PV plants with high maintenance costs or natural conditions that make traditional cleaning methods difficult and inefficient. Small-scale plants are less likely to require such technologies, but if the prices reduce enough, it may become more widespread.

Looking to the future, Eugene Kwak predicts that drone imagery will be able to monitor individual cells in real time and maybe we will start seeing unmanned drones replacing faulty cells all by themselves. Perhaps by that stage we will be seeing UAVs helping in the most unimaginable of areas of our everyday lives, not just in the energy domain. At the time of writing Skycatch drones were even in the process of helping the Nepal Earthquake rescue missions. ■

Some of the problems drones can help detect are explored overleaf

Cedric Brehaut, consultant and market analyst at SoliChamba, and author of the GTM Research report, 'Megawatt-Scale PV O&M and Asset Management: Services, Markets and Competitors', gives an overview of drone and robot use in the solar energy market

"Drones are increasingly popular for solar PV maintenance applications, especially for thermal imaging of large PV plants where they can drastically reduce the cost of scanning large-scale photovoltaic arrays for hot spots and other potential issues. But their adoption has been slow due to regulatory constraints and technical limitations.

"In the United States, for example, drones are illegal or restricted in most urban areas so they are only appropriate for plants in certain remote locations. Some PV maintenance providers work around this problem by using tethered drones, but this reduces the productivity benefit.

"A number of technology firms offer robotic solutions for module washing, although few of these solutions have been deployed in scale.

"There is great potential for cost reduction using robots for module washing, but the robots themselves can be prone to failure and can increase maintenance costs. In regions where water is scarce and expensive, dry cleaning solutions have a stronger value proposition since they can reduce labour costs as well as costly and undesirable water usage."