Automatic Solar Panel Cleaning System

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Abstract- **There are many studies that confirm this as well. Consequently, periodical cleaning of solar panels is very important in order to produce and deliver the maximum amount of energy to the grid. The effect of dirt and dust on the performance of solar panels depends on various factors and always needs to be estimated or evaluated for individual situations. One can generally assume a reduction of about 10%-20% if solar power plants in Europe or the USA are considered. As soon as the installation is located in dry, dusty regions such as the Gulf region, the effect can be increased and make a difference in power of up to 40%. A 300-megawatt solar plant might spend more than $5 million a year on cleaning and lose at least $3.6 million in energy production lost to dust cover. The costs of installing the system—around $11 million for a facility of that size, a bit more than what he estimates is lost each year with a conventional cleaning set-up—can be recovered within 18 months. Cleaning without water also translates to a savings of 110 million gallons (420 million liters) over 10 years.**

INTRODUCTION

The robots are designed as an alternative to the conventional, but also labor-intensive, method of sending human workers to hose and wipe down panels manually or use a truck-mounted sprayer to do so., Dirty panels produce less electricity, but the need to use water for cleaning those panels, especially in dry regions, makes even a clean power project less eco-friendly. And in certain remote corners, water extracted from the ground is too brackish for use without being treated, which adds to the production cost of a solar power plant.

In dusty areas such as the Middle East and India, solar panels could lose electricity production by 10 percent to 35 percent over time if they remain unwashed, Eran Meller, CEO of Ecoppia, told me in a recent interview. robots dry clean each panel and move from the top to the bottom of a row of panels. Using the robots so far has led to about 2-3 percent more electricity production than employing humans, The challenge of keeping solar panels dust free will grow as more solar power projects are built worldwide. In many cases, cheap labor and ample water supply will continue to make manual washing the low-cost choice for solar power plant owners. The airflow removes a bulk of the dust while the brushes get rid of the rest. The robot runs on two 12-volt lead-acid batteries at night. Solar electricity recharges the batteries during the day. After the robot completes its task, it returns to a docking station and uses the rotational energy to get rid of the dust captured by the microfiber. With about one year of field data of its robots' performance, the startup projects that its equipment and services could save 840 million liters of water for a 300 MW solar park over 20 years while increasing electricity sales by $180 million, Meller said. Of course, those projected savings and revenues will vary widely in different countries or even within a country, depending on the local operational costs and how much the utilities are willing to pay for power. Arava, for example, is cleaning its solar panels nightly in Israel while in California, SunPower is cleaning its panels several times a year.

FIG 1. ROBOT FOR CLEANING PANELS

SOLAR PANNEL AND CELLS

FIG: VIEW OF SOLAR CELL PANEL

1) Solar energy conversion cell: - In order to understand how a solar cell works, a little background theory in semiconductor physics is required. For simplicity, the description here will be limited to describing the workings of single crystalline silicon solar cells.

Silicon is a group 14 (formerly, group IV) atom. This means that each Si atom has 4 valence electrons in its outer shell. Silicon atoms can covalently bond to other silicon atoms to form a solid. There are two basic types of solid silicon, amorphous (having no long range order) and crystalline (where the atoms are arranged in an ordered three dimensional array). There are various other terms for the crystalline structure of silicon; poly-crystalline, micro-crystalline, nano-crystalline etc, and these refer to the size of the crystal "grains" which make up the solid. Solar cells can be, and are made from each of these types of silicon, the most common being poly-crystalline.

Silicon is a semiconductor. This means that in solid silicon, there are certain bands of energies which the electrons are allowed to have, and other energies between these bands which are forbidden. These forbidden energies are called the "band gap". The allowed and forbidden bands of energy are explained by the theory of quantum mechanics.

At room temperature, pure silicon is a poor electrical conductor. In quantum mechanics, this is explained by the fact that the Fermi level lies in the forbidden band-gap. To make silicon a better conductor, it is "doped" with very small amounts of atoms from either group 13 (III) or group 15 (V) of the periodic table. These "dopant" atoms take the place of the silicon atoms in the crystal lattice, and bond with their neighbouring Si atoms in almost the same way as other Si atoms do. However, because group 13 atoms have only 3 valence electrons, and group 15 atoms have 5 valence electrons, there is either one too few, or one too many electrons to satisfy the four covalent bonds around each atom. Since these extra electrons, or lack of electrons (known as "holes") are not involved in the covalent bonds of the crystal lattice, they are free to move around within the solid. Silicon which is doped with group 13 atoms (aluminium, gallium) is known as p-type silicon because the majority charge carriers (holes) carry a positive charge, whilst silicon doped with group 15 atoms (phosphorus, arsenic) is known as n-type silicon because the majority charge carriers (electrons) are negative. It should be noted that both n-type and p-type silcion are electrically neutral, i.e. they have the same numbers of positive and negative charges, it is just that in n-type silicon, some of the negative charges are free to move around, while the converse is true for p-type silicon.

Light generation of carriers

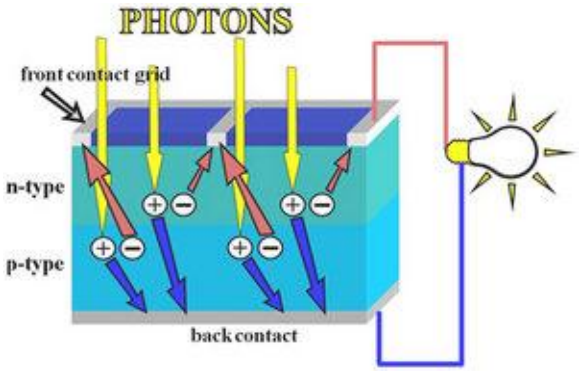

FIG: FLOW OF CURRENT IN BATTERY

The absorption of photons creates electron-hole pairs, which diffuse to the electrical contacts and can be extracted to power electrical devices

OTHER METHODS OF CLEANING

If only a solar project was truly finished once you hooked it up to the grid. We now know better than to expect an array to function at peak production for 20 years without a little upkeep. O&M has grown into a huge business, and module washing is an important segment that shouldn't be forgotten. Just as quickly as system owners have recognized a need for panel cleaning, new technologies have entered the market. No-touch robots offer an alternative to manual washing, and now some techniques avoid water altogether. Both sides say they're better than the other—manual washing may be more precise and of a higher quality while automatic/robotic cleaning

might be quicker and can be scheduled more frequently. What method works best for your system?

Manual Washing

Elite Module Washing, based out of Longmont, Colo., is a manual panel washing team that mobilizes to nearly any location in the United States and abroad. Rather than have Elite affiliates in various cities, CEO Bryan Dirkes said having one team allows him to make sure everyone is qualified and properly trained.

"We hire everyone locally here out of Colorado, and we travel to the sites with our set crews," he said. "Everybody knows their job; everybody knows what they're doing. There isn't any training each day or worrying about if so-and-so can do this."

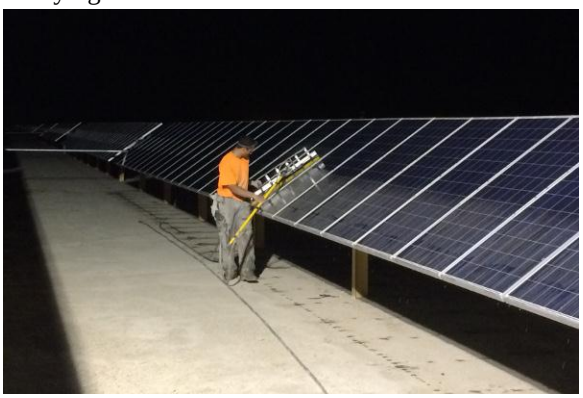

FIG. MANUAL CLEANING SYSTEM

Elite works mostly on utility-scale sites and usually won't take on a new customer unless it's at least 40,000 panels. Contracts are based on how dirty the geographic region is—arid and agricultural areas tend to be dirtier than others and require more frequent cleanings. Often, the beginning of summer is Elite's busiest time because a lot of customers want panels cleaned at the height of the solar season to get maximum output.

Elite only uses water and a soft bristled brush to clean panels. Through local water hookups, the crew filters the water to make sure it's at 0 TDS (total dissolved solids). Dirkes said that even though there are biodegradable soaps, the amount you would need to clean a large utility site with 1 million panels is too much to be comfortable with soaking into the ground. Water does a great job alone.

"Glass is already porous by nature. It has little divots you can't see with your naked eye," he said. "If you use any sort of soap or a squeegee for that matter, it's going to end up filling those pores and you'll get dirt, soap particles, anything stuck. Your glass is eventually going to haze over time."

"Our brushes get in between the frames a bit. A lot of companies that use squeegees don't have that capability," he said. "They pull that squeegee down and it crams that dirt into that bottom rail. If it happens to flip to the other side on a single-axis tracker and it rains, then all that mud and grime is just going to be coming down the top of that panel. It totally defeated the purpose of cleaning. The brushes help push that stuff out of there and a rinse knocks it off completely."

While Elite is contacted after owners notice production has slipped, Dirkes said most business comes during initial budget proposals before projects are even built. The company is currently bidding on projects that won't begin construction for another year or two. This proves that everyone is taking panel washing more seriously.

"We're always improving on our equipment and our procedures. By doing that, it can only make us better and faster," Dirkes said. "We're continuing to strive toward anything we can do to speed up the process or lower the price on something as vital as module washing."

1.1LITERATURE REVIEW

The information on the effects of soiling on solar panels comes from research funded by both universities and solar energy-oriented associations. The studies that were examined all analyzed different aspects of soiling. One study, sponsored by the PowerLight Corporation in Berkeley California, found a daily loss of 0.2% in power output. The report also noted a 7.5% to 12% efficiency increase due to rain 2.

Another study, performed by Boston University's Department of Electrical and Computer Engineering, observed the loss of efficiency from soiling in Lovington, New Mexico. The area had an observed 24% drop in efficiency over the course of a month. The study also found that while rain is the primary cleaning agent for panels, it is not sufficient 3.

The Boston University Study also reported the costs and benefits of three current methods of cleaning solar panels. These methods include natural cleaning through rain and snowfall, manual cleaning, and cleaning by an electrodynamic system (EDS). In general, it was concluded that in order to maximize the cleaning effect of rain, the panels needed to have

a glass shield and be oriented in the near vertical position. Manual cleaning by water and detergent was effective; however, it required costs set aside for labor (45.7% of the total cost) and fuel (20.5% of the total cost). An emerging technology, called an EDS, consists of interdigitated electrodes (made of indium oxide) in transparent dielectric film. The cleaning process is orchestrated by low power, three phase pulsed voltages (from 5 to 20 Hz). This process led to a reflectivity restoration of 90% after only a few minutes.

The University of Sonora analyzed the effect of naturally occurring dust and residue on the energy generation of solar panels4. A standard 'dirt' layer was chosen and was tested on three types of photovoltaic cells, monocrystalline, polycrystalline, and amorphous. The maximum reduction in electric production was 6% for monocrystalline and polycrystalline and 12% for amorphous.

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