Smart Solar Panel Hydrophobic Nano Coating and Cleaning System (An Innovative Higher Solar Power Output Generation Method)

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Abstract- Renewable energy- a most viable option for challenges of energy crisis and global warming. With the advancement of human activities, there is day by day demand for energy. Non-renewable energy has polluted the planet and hugely impacted climate change. To save the planet from the impacts of climatic change, solar energy which is In abundant form of renewable energy can play a vital role as it is safe, renewable & pollution free. Solar PV modules can convert tons of heat (solar energy) into electricity. But these Solar PV modules generally attract Dust accumulation on the PV panel swhich decreases the solar energy reaching the cells, thereby reducing the overall power output.

Indexed Terms- Conventional, Renewable, Solar PV, Hydrophobic etc.

I. INTRODUCTION

Electricity prices are unpredictable, volatile and expensive. What if you were able to take control by getting solar panels?

It's called energy independence -- and it looks different for each person. You may want solar panels to save money on your electric bills, reduce your carbon footprint or protect yourself during a power outage. Whatever your motivation may be, solar panels can produce some or all of your electric needs.

Solar panels have never been this affordable. In 2022, Congress passed the Inflation Reduction Act, which extended the federal residential clean energy credit (formerly known as the solar investment tax credit) until 2034. This federal credit is available for solar purchases in all 50 states and allows you to deduct 30% of the cost of your solar system from your federal taxes. However, getting solar panels could be a bad idea for some. To help you make the most informed decision, here are the pros and cons of getting solar panels.

The pros and cons of solar panels-

Pros

- Cheaper electric bill
- Energy independence
- Produce and use clean energy
- Improve your home's value

Federal tax credit available

By going solar, residential energy consumers can see significant savings in their home energy bills. Electricity prices were up 11.9% year over year in January 2022, while utility gas service prices were up 26.7% year over year, according to the Consumer Price Index. Depending on solar system size and your energy needs, solar panels can reduce or eliminate your reliance on the utility.

Energy independence

Residential solar panels allow you to pull less energy from the grid, resulting in increased energy independence. With the addition of solar batteries, solar panels have the potential to make your home self-reliant and independent from the electric grid. Solar batteries store up energy created during sunny hours,

allowing it to be used at night or on cloudy days. Choosing between an off-grid or grid-tied system will depend on your personal energy goals.

A solar system with a battery can help you power your home during an outage or bad weather. Overall, solar panels give you a level of power stability and flexibility not found in traditional energy sources.

II. LITERATURE SURVEY

Removal of dust using Mechanical Methods -There are different types of methods that are used to clean solar panel. Few of them are mechanical vibration, ultrasonic cleaning, scrubbing and mopping. When brushing is used for cleaning, it is mainly done with the help of brush or scrubber. In these systems a brush is driven by using a machine, which are similar to automobile wipers. But this cleaning method is not that efficient because of the sticky nature and small size of the dust particle. It is also seen that difficult and harsh working condition of the solar power plant make the maintenance of these machines difficult. Also the solar power plant is present over a very large area which makes this cleaning method expensive and inefficient.

The process of blowing of air on the surface of the solar panel is an effective method but it has some negative features such as low efficiency, huge energy usage and difficulty in maintenance of blower arrangement. Mechanical methods of cleaning also include ultrasonic and vibrating method. The factors that are considered in this process include driving methodologies, amplitude and frequency of vibration. Williams R. Brett [1] has used piezo electric and piezo ceramic actuation methods for making self-cleaning solar panel system. These system work on the above described vibrating method.

Removal of dust using Electro-Static Methods-
Technologies for removal of dust using electrostatic methods are mainly based on the “Electric Curtain Concept” by F.B. Tatom and NASA in 1967 and further developed by Masuda at the University of Tokyo in the 1970s [4]. In this technique electr-ostatic and dielectro-phoretic forces are used to raise and transport charged and uncharged particles [5]. In recent past a lot of research has been done to apply this method in space application especially in rovers that are being sent to moon and mars. Electric curtains technology uses a series of parallel conducting electrodes which are embedded in a dielectric surface. Across this surface an oscillation is transmitted between the electrode potentials.

When electrodes are connected to a single-phase AC voltage, a standing-wave field is generated as seen in figure 3. Earlier it was believed that standing-wave fields can levitate particles on the curtain, but not cause a net transport [6].

But if the electrodes are connected to a multi-phase AC voltage, we can create a traveling wave electric curtain as shown in fig 4. If right frequency and amplitude conditions are provided then the charged particle can move along the surface of the solar panel following the electric field. In this manner the surface of the solar panel gets cleaned.[7].

Mazumder [8] designed a flexible electrodynamic screen to protect the solar cell on Martian explorer based on travel-wave field technology.

In suction method, a vaccum pump and a suction cup is used. Vacuum pump sucks air out of the cup and suction cup grips the wall due to external pressure. A semi-independent Wall Climbing Robot with Scanning Type Suction Cup was created and tried by Tomoaki Yano, Tomohiro Suwa, Masato Muraxami and Takuji Yamamotq [9]. This robot used two vacuum pumps. The robot was connected with the gears on the ground through the electric power cables. Experimental results showed that the robot was able to walk on walls, clear steps, and stick on cracks and crevices with high effectiveness.

Cleaner energy source
By installing solar panels on your home, you have a green energy source that does not contaminate the environment with pollutants. Considering the alternative, where the electric power sector contributes up to 28% of all emissions nationwide, having solar energy leads to a much lower carbon footprint. Tapping into renewable energy helps reduce our reliance on fossil fuels -- a resource in decline and harmful to the planet.

Solar panels improve your home's value
The addition of solar panels to a home is considered an upgrade, and therefore should increase the overall value of your home. Solar panels can add around $15,000 of value to your home and can sell quicker than houses with traditional energy sources, according to the US Department of Energy's Lawrence Berkeley National Laboratory.

Cost of panels has decreased over the years
Solar power efficiency has improved greatly over the last 10 years. As solar panel technology improves, so does its return on investment and the savings you'll see over time. Federal solar incentives coupled with state-level incentives (if available) can help make solar panels more affordable and accessible.

30% federal tax credit available to all
In 2022, when Congress passed the Inflation Reduction Act, it extended the previous investment tax credit of 30% through 2032. (It phases out by 2035.) This federal residential clean energy credit covers 30% of the total installed cost of a solar panel system.

Net metering can help speed up payback period
Another alluring feature is how you can speed up your payback period -- the time it takes to earn back your initial investment -- through net metering. Net metering is when you essentially sell your excess energy back to your utility company. Not every state has net metering, so it's important to check with your utility provider.

Solar panel cons
When it comes to any major purchase there are always downsides -- the biggest being cost.

Solar panels are expensive
The cost of a residential solar system will vary by installer and location, but the national average is $31,558, according to the Lawrence Berkeley National Laboratory. Over the past decade, the cost of solar panels has decreased significantly. The federal tax credit can help offset some of the cost, and some states offer additional incentives and rebates, but a solar purchase is still expensive, unaffordable and unattainable for many. Many solar companies or installers offer financing, but that usually means paying interest and adding to the overall cost ever further.

Takes years to see a return on your investment
Understanding how long it takes for solar panels to pay for themselves is a major factor in the purchase decision. Jamie Haenggi, president of ADT Solar, told CNET recently, the average payback period in the US is between six to 12 years, but the energy market is so volatile, that figure is closer to 12. If you are looking to get solar panels to save money in the long term, then the payback period is important. For example, if it takes you seven years to recoup your investment, and you move or sell your home before that event takes place, then you might be taking a loss.

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Not everyone has the right conditions
Available sunlight, space constraints and installation hurdles can make adding a solar system even more expensive. Trimming trees and repairing your roof are just a few factors that can influence a solar system's price tag. The angle, pitch and direction of your roof will affect the productivity and efficiency of your solar panels. The ideal situation requires the right pitch -- an angle of 15 and 40 degrees, according to the Department of Energy -- and access to our roof's pitch and access to sunlight can prevent solar panels.

Potential to raise property taxes
Property taxes are based on assessed values of property. Adding solar panels to your home will increase the appraised value. Typically, the higher the home's value, the more you will pay in property taxes. Some states have policies in place to prevent an increase due to a solar system addition. See which

states have property tax exemptions and which do not here.

Need to add panels to homeowner's insurance policy
Some homeowner's policies cover solar panels, some do not. It's best you check with your insurance provider or shop for a new one that will cover a new solar installation. Insurance policy premiums could increase to account for solar panel coverage.

Accessibility and affordability all depend on where you live
While everyone can benefit from the 30% federal tax credit, not all states offer or enforce additional incentives. Parts of Kansas, for example, aren't covered by the state's net metering law. Dorothy Barnett, executive director of the Climate + Energy Project, told CNET recently "It's possible you won't be able to net meter a system currently," or may be charged an additional interconnection fee. In contrast, states like Rhode Island, Maryland and California have more generous incentives including net metering, property tax exemptions and grants such as the Maryland Energy Administration's Low Income Solar Grant Program.
Geographic location also has an impact on your solar panel's efficiency. For example, Alaska residents see fewer sunny days per year compared to Florida, where sunny days are above the national average.

Solar storage is an additional expense
If you want to store excess energy from a solar spaniels system during periods of sun so that you can also power your home at night, solar batteries are a must. But they are not cheap. In fact, the addition of solar batteries could double the total cost.

Solar panel production and its environmental impact
The manufacturing of the materials that make up solar panels has an impact on the environment making the "energy payback" timeline a factor to consider. However, when it comes to greenhouse gases, solar panels pay for themselves within one to four years of use, according to a report by the Office of Energy Efficiency and Renewable Energy.

Solar panels are not easily transferable
Solar panels are not easily transferable for one house to the next and not likely worth the cost to move. With that in mind, if you plan to move or sell your home before your payback period is up, you never actually see a return on your investment.

Is going solar worth it?
It depends on what is motivating the household to make the decision to [install] solar," Becca Jones-Albertus, director of the US Department of Energy Solar Energy Technologies Office told CNET. For example, if you're eager to participate in renewable energy, but don't want the upfront cost, you can look into the power purchase agreement or a community solar program. If you are looking to be 100% energy independent, live off the grid, are not planning on moving for many years, and your state has net metering, then solar panels could be worth it. Even after weighing all the pros and cons, the decision to go solar is a highly personal one. Make sure to compare quotes from multiple solar companies and installers before making a decision.

III. PROBLEM DEFINITION

Why cleaning is needed for solar panel?
Dust plays a negative role in energy production from the solar panels.

Accumulation of dust on the surface of a photovoltaic module decreases the radiation reaching the solar cell which results in voltageand power losses. Dirt, bird poops, pollens prevent the sunlight reaching the solar cells

The above affects the performance of panels leading to less energy production

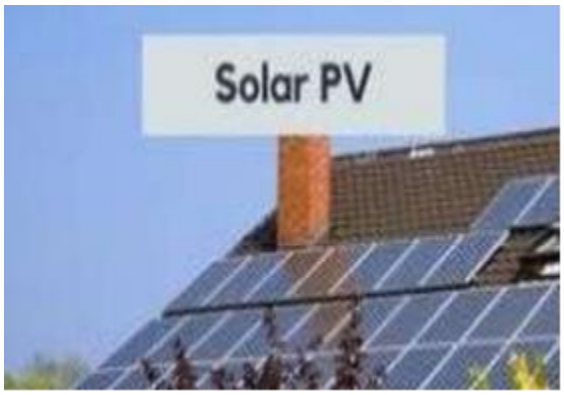
The average daily energy loss caused by these deposits on the surface of the PV module ranges between 4 % to 20%. In desert areas, the reduction in solar efficiency due to dust on PV panel can be as high as 40%

Cleaned solar panels have the potential to work more efficiently interms of performance than the uncleaned solar panels.

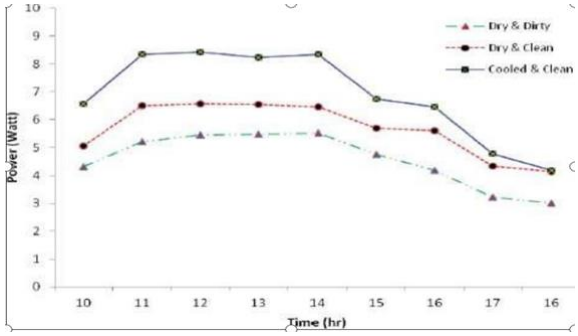
IV. METHODOLOGY

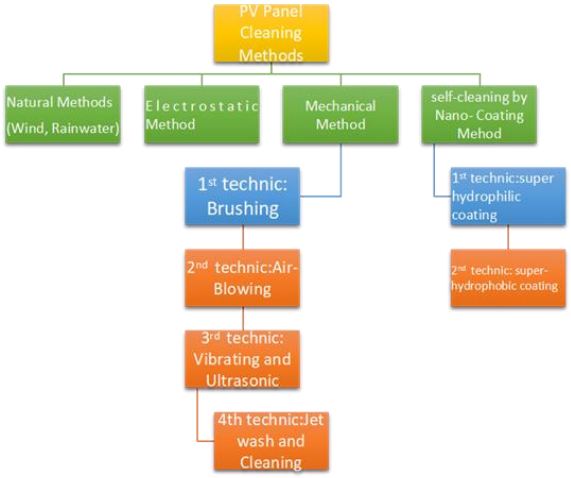
Solar Thermal Panels used in industrial applications for heating purposes

Solar PV Panels used for generating electricity for residential & commercial applications and use



Effect of dust on power production of solar PV module





Comparison of 4 solar panel Cleaning methods

	Cleaning Method	Main Advantages	Main Disadvantages
1	Natural Method (Wind, Rain Water)	No cost Cleaning by nature	Seasonal Cannot wash away , the hard build up of bird droppings/dust
2	Electrostatic Method	Dust particles fly away from the panel surface due to the effect of electrostatic force	Inefficient and does not work well at all times.
3	Mechanical Method	Efficient way of cleaningthe Panels using tools / hose connections etc. Removes hard built up of	Time consuming, Labor sive Danger of harming the coveringof the boards while

		dust and bird droppings	brushing.
4	Hydrophobic Nano Coating	Does not allow dust to stick on to the panel's surface; No scratches on PV surfaces	No major Disadvantages other than time and labor.

V. WORKING

Observation- Hydrophobic Nano Coating Method is the best and most efficient way of keeping solar panel cleaning.

An Introduction to
SMART SOLAR PANEL NANO COATING AND CLEANING SYSTEM

- Our objective is to help in getting optimal solar power output on a consistent basis.
- Solar efficiency can be greatly compromised by dirt & bird faces collecting on panels.
- Clean, dust free solar panels increase efficiency and effectiveness of power generation
- We are introducing a unique methodological Smart Solar panel Cleaning System- a combination of Hydrophobic Nano-Coating (once in two years) and periodic easy jet wash.

Our hydrophobic anti-reflective nano-coating solution has special properties of repelling water, diluting dust accumulation and making subsequent process of periodic jet washing much easier and smoother with less water consumption.

SOLAR HYDROPHOBIC NANO COATING

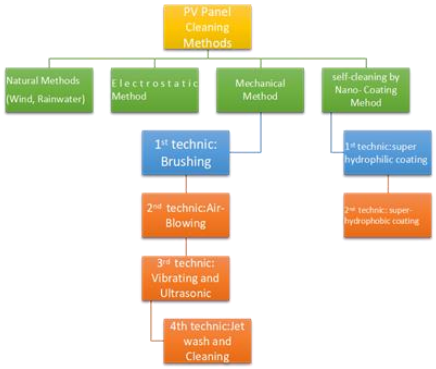
Hydrophobic Nano-coating application on Solar Panels as pre-treatment before regular washing and cleaning

Picture of a hydrophobic treated panel where water accumulates into droplets for easy roll down

Picture depicting self-cleaning & rolling down of water droplets Carrying dust particles on a hydrophobic surface

Method of Solar Panel Cleaning

SMART SOLAR PANEL COATING AND CLEANING SYSTEM



PRESSURE JET CLEANING

REGULAR CLEAN PANEL

PRESSURE JET CLEANING

PRESSURE JETFOMING

PANEL SCRUBBING

MOPPING ANDDRYING

PRE CLEANING

NANO COATING

NANO COAT BUFFING

HYDROPHOBIC ACTION

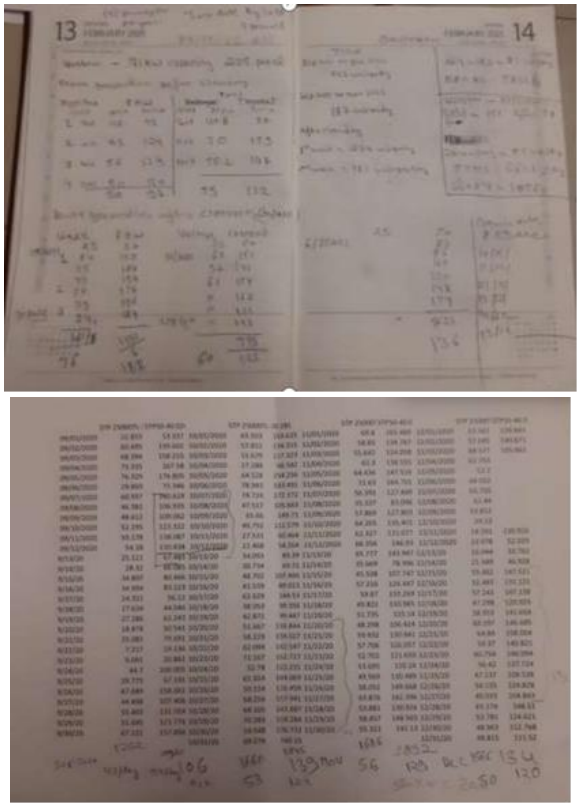
SMART SOLAR PANEL NANO COATING AND CLEANING SYSTEM

VI. ANALYSIS OF FINDINGS & PROOF OF CONCEPT (CALCULATION)

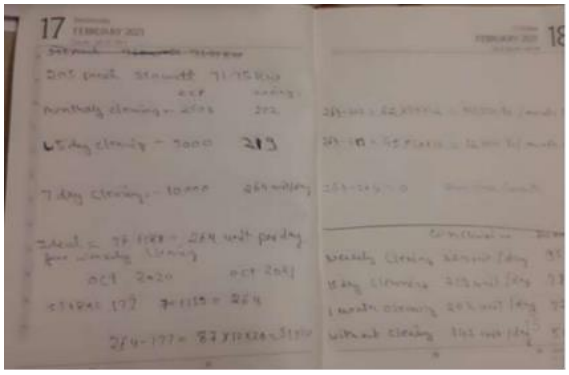
A Case study of 50 KW Solar Panel Installation @ M/s. Spartan Electricals, Wagle Estate Thane.

- In best conditions, a 50 KW Solar Power Installation should generate close to 200 units of
- Power output per day.
- However, to achieve this optimal power output one needs to do a weekly cleaning of the
- Panels to protect from dust and dirt accumulation.
- Our NANO-COATING which sustains for 2 years on application, dilutes the dust and
- dirt accumulation, and ensures better radiation of sunrays.
- The weekly regular cleaning is now REDUCED to only once in 2 weeks which meanscleanings in
- year reduced from 52 to just 24 cleanings – COST SAVING
- Power Outputs ranged between 190-195 units per day (90-95% efficiency).
- Maintenance becomes much more economical- Cost saving in cleaning frequency, along with
- cost of Nano-Coating of once in 2 years getting covered.

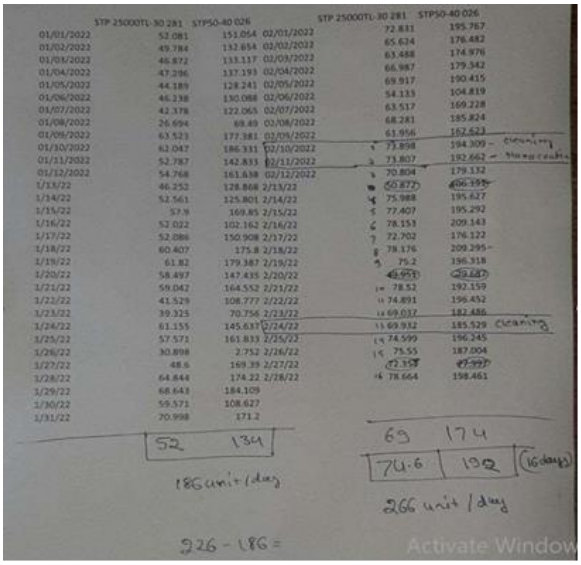
Daily data logs maintained from year 2020 till Feb 2022 that were used to Analyse the performance



Some samples of the data logs used as reference for Analysis



We did Nano Coating + Four Cleaning sessions every 15 days



Findings: Comparison Chart - Before and After Case Study of 50 KW solar installation @ M/s- Spartan Electricals, Thane

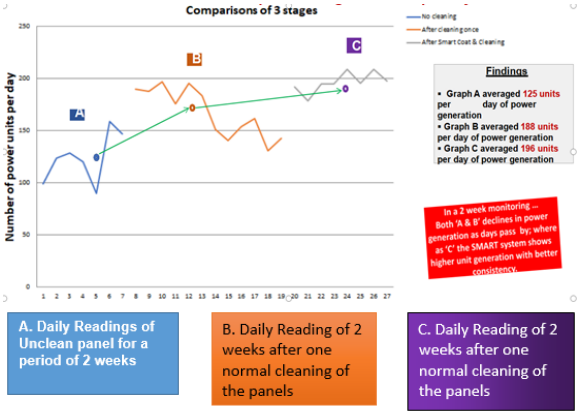
A. Before Cleaning		B. After normal Cleaning once				C. After SMART System Application /Execution (Super HP Coat +Cleaning)	
		1-6 days after cleaning		7 to 12 days after cleaning			
Date	Average Output/Day	Date	Average Output/Day	Date	Average Output/Day	Date	Average Output/Day
Sep 2020	99	25.10.21	190	31.10.21	151	11.2.2022	192
Oct 2020	124	26.10.21	188	1.11.21	141	12.2.2022	179
Nov 2020	129	27.10.21	197	2.11.21	154	13.2.2022	195
Dec 2020	120	28.10.21	176	3.11.21	162	14.2.2022	195
Avg	118	29.10.21	196	4.11.21	131	15.2.2022	209
Sep 2021	90	30.10.21	184	5.11.21	143	16.2.2022	196
Oct 2021	159					17.2.2022	209
Nov 2021	147					18.2.2022	198
Average	132	Average	188.50	Average	147	Average	196

Very low output much below Ideal output of 200 Units

Gain of 8 Units/ Day
C- A Efficiency (95 % + Gain 8 @ 14 = (+ Rs 122)

LOSS OF 41 Units Per Day @ Rs. 14= (- Rs. 574/- Per Day
Efficiency = approx 80 % to 85 %

Readings of a 50 KW Panel installation after SMART COATING + CLEANING treatment Ideal Threshold level output – average 200 units per day



CONCLUSION

Based on the findings of our experiment and trials at Solar Panel Installations of M/s. Spartan Electricals, Thane

- Solar Panels if not cleaned at least once week, the daily power generation
- declined day by day @ around 2- 5 % daily so much so that after about 4-6
- weeks, the output nearly reduces by 40-50%.
- Therefore, depending only on natural cleaning in monsoon season will only
- result in loss of power unitgeneration and lower return on investment.
- Going by the findings, a regular cleaning of the panels is necessary once
- every week if one has to get best output. However, even with this regular
- weekly cleaning of the panels, the average daily output is likely to be
- inconsistent and about 10-12 % below the threshold level of 200 units
- per day.
- Our SMART COATING & CLEANING SYSTEM , entails a One-time coating in
- 2 years and a fortnightly cleaning. The findings have proven to give
- Optimum results close to the threshold level of 200 units per day with
- Consistency across 15 days after the coating treatment.
- Thereafter only cleaning is required in 15 days' interval.

Overall Gain /Loss Calculation Summary

- Regular weekly cleaning for 2 years costs Rs. 4 lakhs , resulting in average daily
- output of 188 units - a loss of 8 units per day (i.e.loss of 4800 units
- in 2 years = minus Rs. 192,200 in 2 years
- SMART system Coating + Fortnightly Cleaning for 2 years costs Rs. 2.75 Lakhs ,
- with average daily output of 196 units - a gain of additional 8 units per day
- (i.e gain of 4800 units in 2 years) = plus Rs. 192,200 in 2 years

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